Volume 14 APRIL, 1935 Number 4

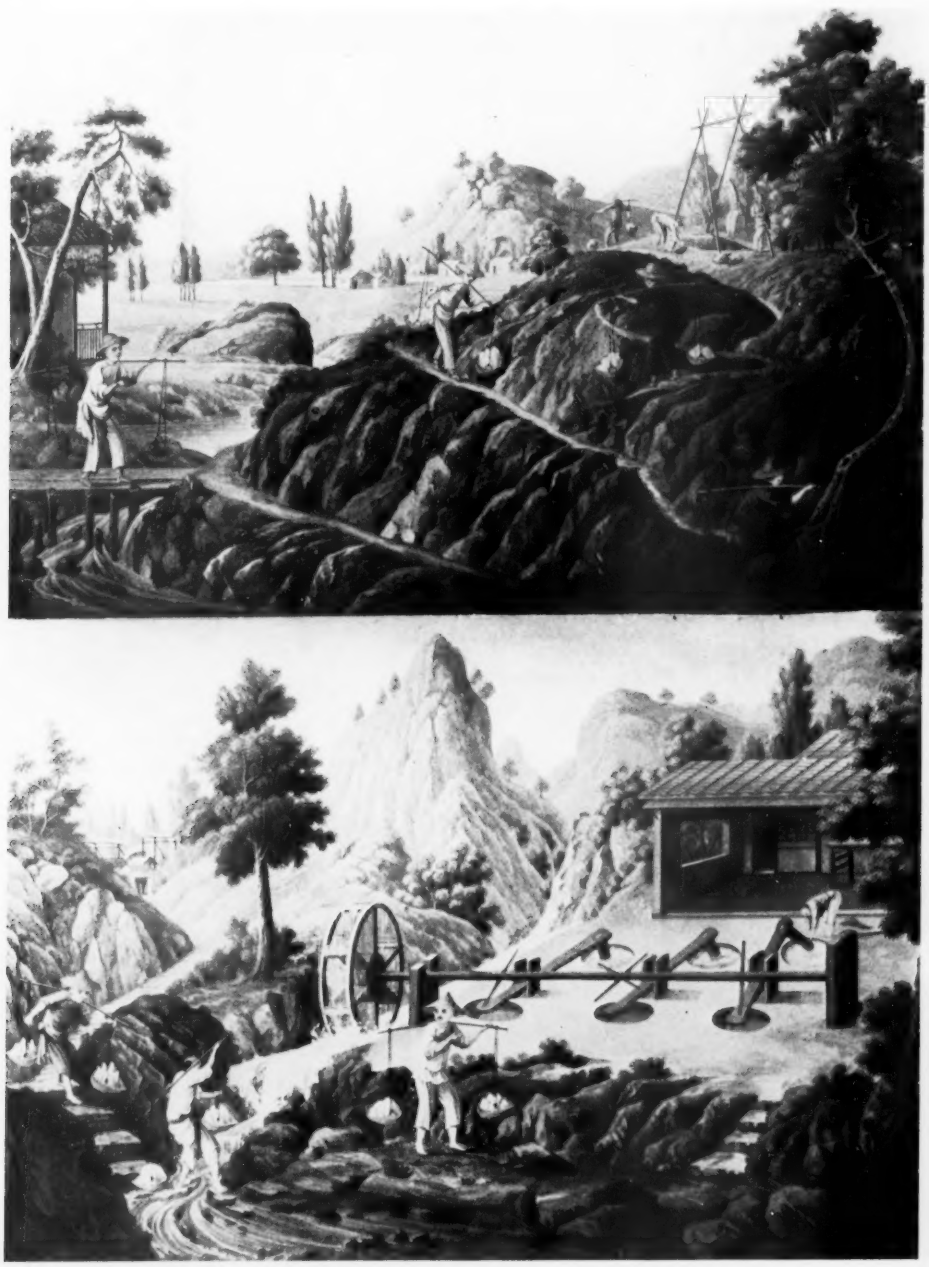
THE BULLETIN

OF THE

AMERICAN CERAMIC SOCIETY

■ The manner in which Chinese of the 18th Century mined and blunged the clay used in porcelain manufacture is shown in these illustrations. (See page 134 for a description of the kind of clay used in the manufacture of Chinese porcelain.)

A brief description of one of the modern ceramic laboratories recently established in China is given on page 148.



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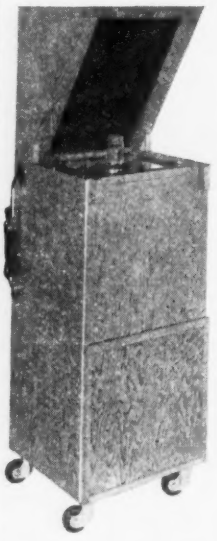

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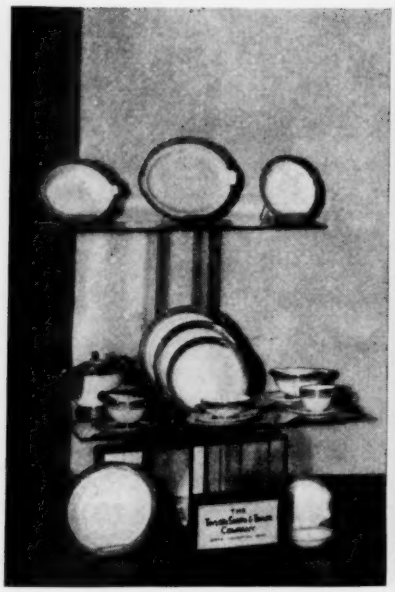

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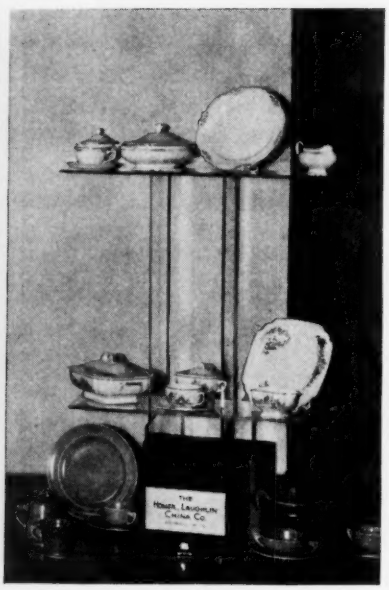

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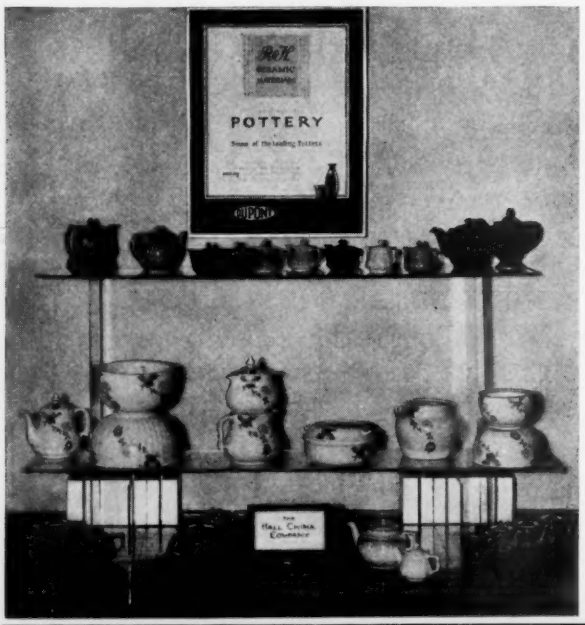

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of Technical, Scientific, and Art Questions

Vol. 14 April, 1935 No. 4

PAPERS

PETROLOGY OF THE PENNSYLVANIAN SHALES AND NONCALCAREOUS UNDERCLAYS ASSOCIATED WITH ILLINOIS COALS. PART II

By Ralph E. Grim

Including X-Ray Studies by P. F. Kerr and Chemical Studies by O. W. Rees

Editor's Note: Part I of this paper was presented in the March issue of *The Bulletin*, pp. 113–19. A synopsis of the complete paper was given on page 113 of that issue. Another installment will be published in the May issue of *The Bulletin*.

Part II covers sections III (B), III (C), and IV (A) (see synopsis, p. 113, March, *Bulletin*).

(B) Constitution of the Coarser Grade Sizes (Fraction B) of the Shales above Coals

Fraction B includes the shale particles too large to remain in suspension. It ranges from almost nothing to 60% and more in shaly sandstones or siltstones. Fraction B most commonly comprises about 25% of the sample.

The mineral components of this fraction include quartz, muscovite, chloritic material, biotite, calcite, pyrite, siderite, feldspar, zircon, tourmaline, apatite, epidote, rutile, garnet, common hornblende, anatase, brookite, glauconite, corundum, staurolite, gypsum, and sillimanite. In addition, certain fraction B samples also contain aggregates and flakes of the sericite-like clay mineral reaching 0.1 millimeter in maximum diameter, which have not been broken to a size permitting their suspension.

(1) Quartz Quartz is invariably present and usually makes up 80% or more of fraction B. It occurs in angular irregular grains with a usual maximum diameter of 0.06 millimeter. In a few samples, grains with a diameter of 0.15 millimeter are present and these larger grains often show slight rounding. Extinction shows no straining of the grains. They commonly contain inclusions, particularly of the acicular type.

(2) Muscovite Flakes Muscovite flakes are to be found in most but not all shales. Where present, the quantity ranges from less than 1% to about 15% of fraction B. The average maximum diameter is about 0.1 millimeter but in a few it is as much as 0.3 millimeter. The following optical data determined from flakes in a number of different fractions indicate that the mineral is muscovite: $\gamma = 1.596$; $\gamma - \alpha = 0.033$; $(-)$; $2V = 38°$. Commonly flakes and masses can be found with a lower index of refraction and lower birefringence, and some of them show gradations to optical data characteristic of the sericite-like clay mineral, thus suggesting a genetic relation between them.

(3) Chloritic Material Chloritic material occurring in flakes and flaky aggregates is common in many shales but usually makes up less than 5% of their total. Individual flakes have an average maximum diameter of about 0.1 millimeter, occasionally reaching 0.25 millimeter. The material ranges from light to dark green. As the color darkens, the index of refraction (γ) ranges from 1.610 to 1.660. Its birefringence is low, $2V$ is small, the sign is $(-)$, and the material has the characteristic pleochroism of chlorite. In certain samples there is a pronounced alteration of the mineral to limonitic material. The presence of felted flaky grains of intergrown white mica and chloritic material is characteristic of a few samples (Fig. 3). This intergrowth and the gradation between the two types of mica shown by these grains suggest a genetic relation between them.

(4) Pyrite Pyrite is common to abundant in some of the shales. It occurs in large lenticular and

nodular aggregates reaching many millimeters in diameter and is disseminated through the shale as minute (0.06 mm.) grains. The individual grains and the components of the aggregates show excellent crystal forms. Much of the pyrite is somewhat altered to limonite.

(5) Biotite Biotite is a common constituent in fraction B of a few shales. It occurs in flakes reaching 0.25 millimeter in diameter, many of which include abundant rutile needles. Some of the flakes appear to be altering to chloritic material, although it is often impossible to determine definitely the direction of the change, *i.e.*, whether the biotite is altering to the chloritic material or forming from it.

(6) Calcite Calcite is a common to rare constituent in fraction B of a few samples. It occurs in irregular grains and aggregates reaching a maximum diameter of about 0.06 millimeter.

(7) Siderite Siderite occurs in large concretions and layers and also in minute disseminated grains in certain of the shales. The small grains usually have a maximum diameter of less than 0.03 millimeter and show well-formed crystal outlines.

(8) Feldspar Feldspar is extremely rare and when found makes up only a part of 1% of fraction B. Albite and orthoclase are the common types present. The individual grains show little or no alteration.

(9) Other Minerals Other minerals present in fraction B are zircon, tourmaline, apatite, epidote, rutile, garnet, common hornblende, anatase, brookite, glauconite, corundum, staurolite, gypsum, and sillimanite. The total quantity of these minerals in fraction B of any one sample is usually less than 1%. Zircon and tourmaline are much more abundant than the others, and they often are present in two distinct types, (1) a well-rounded type, and (2) a type in which the presence of crystal terminations shows that there has been little or no rounding, thus suggesting that some of the constituents of the shales have come directly from their primary source rock, whereas others have passed through more than one cycle of sedimentation.

These minerals, except glauconite, are angular or show only a small amount of rounding. They show little or no alteration. They are invariably small, rarely reaching 0.06 millimeter in diameter.

In the material studied, there is no distinct correlation between the identity or characteristics of these minerals and their stratigraphic or geographic distribution.

(C) Detailed Description of a Series of Representative Shales

The series of shales to be described has been selected to illustrate their range in composition and texture.

(1) Purington Paving Brick Co. Pit Galesburg, Knox County. Sample of gray-blue shale weathering gray-brown from the lower part of a 40-foot exposure of Purington shale which overlies the Francis Creek shale (sample No. 240).

This shale is composed of about 60% sericite-like mineral, 10% muscovite and chloritic material, and 30% quartz. The sericite-like mineral occurs in flakes usually too small for size determination, but occasionally reaching 0.03 millimeter in their greatest diameter. The individual particles show little uniformity of orientation. Some of them occur in spherical aggregates sharply separated from the enclosing material.

The chloritic material occurs in flakes and irregular patches reaching a maximum diameter of 0.1 millimeter. Muscovite occurs in flakes reaching 0.2 millimeter in diameter. Some of the particles of chloritic material and muscovite grade into the surrounding sericite-like mineral (Fig. 3). Because of this gradation, it is often difficult to identify the mineral constituents of the matrix of this shale. Other flakes of muscovite and chloritic material are sharply separated from the enclosing material and some of them are wrapped around the quartz grains.

FIG 3.—Felted mass (*m*) of chloritic material and muscovite grading into the matrix (Sample No. 240) Purington Paving Brick Co., Galesburg. × 200.

The quartz occurs in scattered grains with a maximum diameter of 0.12 millimeter. Many of the grains show the presence of secondary quartz around their periphery.

(2) Whitehall Sewerpipe and Stoneware Co. Pit Whitehall, Greene County. Sample of gray-blue well-bedded shale from the lower part of a 6-foot horizon of Purington shale above the Francis Creek shale and coal No. 2 (sample No. 235).

This shale appears to be composed entirely of the sericite-like mineral which occurs in minute flakes reaching a maximum diameter of 0.002 millimeter. The flakes are yellow-gray and they show a high degree of uniformity of orientation.

A distinctive feature of this shale is the presence of canoe-shaped masses of the sericite-like mineral (Fig. 4), sharply separated from the enclosing matrix composed of the same mineral. The masses have a maximum diameter of several millimeters, and their long axes are either parallel to the bedding or cut across it at a low angle. They differ from the matrix in possessing a brown color, probably due to the presence of some organic substance, in having a slightly different orientation of their constituents, and in the larger size of particles in the center of the masses.

Their origin is not clear. However, their regular shape and the presence of organic material in them suggest that they are secondary after organic remains, possibly spore material. Their shape appears to be too uniform and regular to consider them as depositional aggregates.

(3) Poston-Springfield Brick Co. Pit Springfield, Sangamon County. Sample of well-bedded shale from the upper part of an exposure of Trivoli shale above coal No. 8 (sample No. 243).

The sericite-like mineral makes up 60% of this shale and the quartz, 40%. The former occurs in light yellow-green flakes varying in size up to 0.04 millimeter. The larger flakes are bent, frayed at their ends, and grade into a matrix of smaller particles. There is little uniformity in the orientation of the larger flakes; many of them occur at a high angle with the bedding, whereas the smaller ones are usually parallel with it.

Quartz, which occurs in angular grains as much as 0.04 millimeter in diameter, is scattered or concentrated in lenses and streaks. Many of the grains show marginal addition of secondary silica.

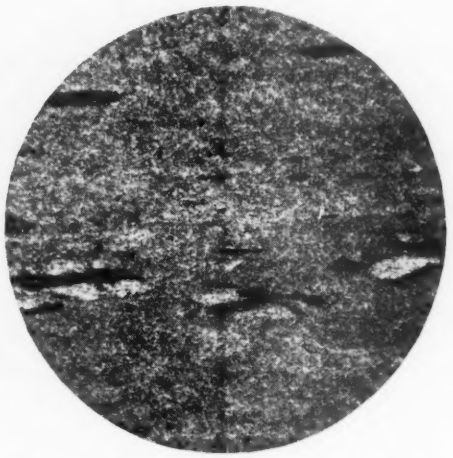

FIG. 4.—Lens-shaped aggregates of clay mineral particles in the matrix. (Sample No. 235) White Hall Sewerpipe and Stoneware Co., White Hall. × 200.

A few flakes of muscovite are distinctly separated from the matrix and a considerable quantity of yellow-brown, probably limonitic, material is disseminated through the matrix. Different minute beds vary slightly in the abundance of the limonite, in the degree of uniformity of orientation of their mineral constituents, and in the relative abundance of their quartz grains. These variations produce the laminated structure of this shale.

(4) Hydraulic Press Brick Co., Haydite Plant Pit Near O'Fallon, St. Clair County. Sample from upper part of blue-gray shale occurring below the Collinsville limestone (sample No. 279).

The shale is composed of about 50% sericite-like mineral forming a matrix surrounding 45% quartz and 5% muscovite, chloritic material, and calcite. The sericite-like mineral occurs mainly in gray-yellow flakes reaching 0.005 millimeter in diameter. These flakes occur mainly in the interstitial spaces between the quartz grains and show little uniformity of orientation. The detailed characteristics of the matrix are largely concealed by an abundance of brown organic material which acts as stain. Micaceous books of yellow-brown sericite-like mineral that grade into the matrix are as much as 0.15 millimeter in diameter.

The angular, unsorted quartz grains have a maximum diameter of 0.06 millimeter. They show no regularity of distribution.

Muscovite flakes ranging up to 0.2 millimeter in diameter are scattered through the matrix and their margins often grade into the matrix. The chloritic material occurs in flakes and irregular patches which also show transitional boundaries into the matrix. The shapes of the scattered masses of calcite occasionally suggest that they are organic remnants.

(5) Albion Brick Co. Pit, Plant No. 1 Albion, Edwards County. Sample of gray poorly bedded shale from upper 20 feet of this exposure of upper Pennsylvanian shale (sample No. 264).

This shale is composed of about 35% sericite-like mineral, 40% quartz, 20% muscovite, and 5% chloritic material and biotite.

A considerable quantity of red-brown translucent material occurring in patches and streaks and disseminated through the rock makes it difficult to identify the constituents. The sericite-like mineral occurs in minute gray-yellow flakes which exhibit little uniformity of orientation.

Muscovite flakes reaching 0.75 millimeter in diameter show little uniformity of orientation. Some of the flakes are sharply bounded, whereas others show transitional boundaries with the sericite-like mineral forming the matrix.

The quartz occurs in angular grains with a maximum diameter of 0.2 millimeter. They are unsorted and either scattered or concentrated in streaks and lenses. In the lenticular masses, the presence of mutually accommodating boundaries indicates the post-depositional transfer of some si ica.

The biotite and chloritic material occur in flakes reaching 0.4 millimeter in length. Many of the flakes of chloritic material appear to grade into the matrix.

IV. Noncalcareous Underclays and Shales Occurring below Coal Horizons

In the cyclical repetition of beds, the coal is usually directly underlain by noncalcareous underclay which often grades downward into either calcareous underclay or shale. In some places, either the calcareous underclay or the shale occurs directly beneath the coal. The present investigation of the underclays has been limited to materials utilized commercially, and calcareous underclays have not been included. Twenty-one samples were studied (Appendix II).* Samples

* Appendix II will be published in a succeeding installment.

Nos. 224, 252, and 268 are from a shale horizon beneath coals, and separated from them by a thin underclay.

The noncalcareous underclay is light to dark gray in color, is not bedded, and has a characteristic irregular angular fracture. A further characteristic is the presence in it of many small irregularly scattered, slickensided surfaces along which it usually breaks.

The calcareous underclay has essentially the same megascopic characteristics as the noncalcareous underclay. The underlying shale is similar in appearance to the shale occurring above the coals.

(A) Constitution of the Finer Grade Sizes (Fraction A) of the Noncalcareous Underclays and Shales beneath the Coals

Fraction A varies in relative abundance in different samples from about 50% to almost 100% of the total rock.

With high magnification (1000 diameters) this fraction of every sample proved to be entirely crystalline. Fractions from Nos. 224, 268, and 252, which are shales, were identical in all their petrographic data with those given for similar fractions in the shales occurring above the coals.

Fraction A of the remaining samples, which represent the noncalcareous underclays, is composed of colorless flake-like particles and appears to be homogeneous, although in a few instances particles can be detected that seem to have a slightly lower index of refraction and may be quartz. The extremely minute size of the particles (maximum diameter 0.002 mm.) prohibits an absolute determination of homogeneity.

(1) Optical Data The optical data for the colorless flake-like mineral constituent varies within narrow limits in fraction A of different underclays thus, γ ranges from 1.562 to 1.569, and $\gamma - \alpha$ ranges from 0.012 to 0.020 (Appendix II).* The sign is (−), and $2V$ is medium.

The optical properties of this fraction of the underclays differ from similar fractions of the shales in possessing a lower index of refraction and a lower birefringence. Considered as diagnostic criteria, these data for the underclays occupy an intermediate position between similar data given for the sericite-like mineral of the shales and kaolinite. Indeed, all variations from optical constants close to those of the sericite-like mineral to those approximating kaolinite[18] have been found (Appendix II).* These constants do not coincide closely with the optical constants for other known clay minerals. They suggest, therefore, that fraction A of the noncalcareous underclays is composed either of a mixture of kaolinite and a sericite-like mineral like that in the shales, or one constituent occupying an intermediate position between the sericite-like mineral and kaolinite. The range in the optical data further suggests that different underclays contain either mixtures of all proportions from almost pure kaolinite to almost pure sericite-like mineral, or that the single constituent is one of a series of constituents between these two minerals and that different members of the series are to be found.

(2) X-Ray Data X-ray analyses were made of fraction A of all samples listed in Appendix II by Kerr,[19] using the same technique as employed in analyzing the shales. According to Kerr, samples of fraction A of the shales below coals Nos. 224, 268, and 252 yield diffraction patterns similar to those yielded by fraction A of the shales overlying the coals.

The diffraction patterns of fraction A of the remaining samples, which are of noncalcareous underclays, contain the same sericite-like minerals as exist in the shales and fine quartz, in addition to kaolinite. The lines of the patterns due to the sericite-like mineral and those resulting from the quartz are much less intense than corresponding lines in the patterns of fraction A of the shales, from which it is inferred that the clays contain a relatively smaller quantity of these minerals than the shales. On the other hand, lines that are seemingly due to kaolin are correspondingly stronger.

It can be concluded, therefore, on the basis of the X-ray evidence that fraction A of the noncalcareous underclays is essentially composed of kaolinite plus varying amounts of the sericite-like mineral and quartz.

Samples Nos. 48 and 245 yield patterns slightly different from those of the other underclays studied. From the standpoint of their diffraction patterns, these two may be classed as

* Appendix II will be published in a succeeding installment.

[18] C. S. Ross and P. F. Kerr, "The Kaolin Minerals," *U. S. Geol. Surv. Prof. Paper*, No. 165-E, p. 168 (1931).

[19] See footnote 6, *Bull. Amer. Ceram. Soc.*, **14** [3], 115 (1935).

impure kaolins. Quartz lines and the sericite-like mineral lines are also present, but they seem to be much less conspicuous than in the patterns of the other underclays. This indicates that certain underclays may be composed almost wholly of kaolinite.

(3) Chemical Data Chemical analyses of fraction A of the shales and underclays below the coals are given in Table III. Analyses of these fractions from Nos. 224, 252, and 268, which are from shale horizons below coals, are the same in all details as those given in Table I* for similar fractions froms hales overlying coals, and the same conclusions concerning their gradation can be traced in the decreasing water content, the increasing K_2O content, and increasing silica-to-alumina ratio.

These chemical data suggest that fraction A of certain of the noncalcareous underclays (No. 206) is essentially kaolinite and that fraction A of other noncalcareous underclays (No. 225) contains appreciable quantities of the sericite-like mineral in addition to the kaolinite. These data further suggest that in fraction A of most of the underclays studied, kaolinite is the dominant mineral with only small amounts of the sericite-like mineral. Whether or not the majority of all the underclays in Illinois, particularly the calcareous

TABLE III

CHEMICAL ANALYSES OF FRACTION A OF NONCALCAREOUS UNDERCLAYS AND SHALES UNDERLYING COALS†

	207	212	48	284	271	206	225	205	252	268	224
SiO_2	50.48	49.81	48.33	53.32	50.10	49.84	54.88	51.96	51.43	51.45	49.27
Al_2O_3	31.13	32.75	33.27	31.09	33.76	33.66	26.38	30.60	29.02	26.82	27.87
Fe_2O_3	1.01	1.30	0.62	1.57	1.24	1.04	0.81	1.32	1.88	2.07	2.32
FeO	0.47	0.63	0.53	0.00	0.46	0.69	0.90	0.80	2.66	3.01	3.22
MgO	0.79	0.64	0.22	0.69	0.52	0.47	0.85	1.09	1.52	1.89	2.49
CaO	0.34	0.69	0.61	0.83	0.49	0.62	0.27	0.97	0.62	0.65	0.69
Na_2O	0.20	0.19	0.53	0.26	0.32	0.11	0.11	0.31	0.42	0.29	0.58
K_2O	1.86	1.25	1.27	0.59	0.45	0.21	2.94	1.94	3.40	5.15	4.37
TiO_2	1.90	1.89	2.19	1.56	1.57	1.45	3.08	1.72	1.56	1.80	1.69
Ignition loss		10.61	11.95	10.36	11.05	12.13	9.19	10.00	8.18	7.23	7.84
P_2O_5			0.44				0.54				
Total		99.76	99.96	100.27	99.96	100.22	99.95	100.71	100.69	100.36	100.34
H_2O+	10.38	10.11		10.19	11.13	12.21		9.98	7.77	7.31	7.83
H_2O-	1.90	1.54	0.85			1.24	0.48		1.04	0.87	0.65
Total	100.46										
SiO_2/Al_2O_3	2.75	2.58	2.47	2.91	2.52	2.52	3.54	2.89	3.01	3.26	3.00

composition can be reached. The analyses of the remainder of the samples, *i.e.*, the noncalcareous underclays, show in general a lower content of K_2O, MgO, FeO, Fe_2O_3, a higher H_2O content, and usually a lower silica-to-alumina ratio.

Computations of analysis No. 206 show it to have a silica-to-alumina ratio of 2.5 and 2 molecules of water, suggesting that this sample was composed of a member of the kaolinite-anauxite isomorphous series. The analysis of sample No. 225 closely resembles the analyses given in Table I for fraction A of the shales in its low water content, high K_2O content, and high silica-to-alumina ratio. An inspection of Table III clearly shows analyses of fraction A, representing all gradations from that of sample No. 206, which has the composition of a member of the kaolinite-anauxite series, to sample No. 225 whose composition resembles somewhat that of fraction A of the shales, although most of the other analyses in Table III are closer to the composition of kaolinite. This underclays, are essentially kaolinite requires the investigation of additional material.

TABLE IV

DEHYDRATION OF FRACTION A OF NONCALCAREOUS UNDERCLAYS AND SHALES UNDERLYING COALS†

Temp. (°C)	Moisture loss (%)				
	252	268	271	212	206
110	0.70	0.24	2.31	1.56	1.79
160	0.79	0.47	2.53	1.65	1.95
250	0.85	0.89	2.92	1.84	2.26
300	1.23	1.38	3.41	2.24	2.64
350	1.43	1.79	3.73	2.41	2.88
375	1.54	2.18	3.92	2.79	4.11
400	2.22	2.39	4.51	3.07	4.33
450	5.48	3.31	9.25	8.53	5.22
485	6.10	6.06	11.35	9.88	11.85
530		6.86	11.23		
540	6.93			10.48	12.79
615	7.70	7.51	13.01	11.27	13.59
650	7.55	7.48	13.02	11.31	13.92
700		7.79	13.30		
750	7.67	7.89	13.60	11.50	14.22
1000	8.17	8.45	14.08	12.02	15.55

† Determinations made under the supervision of O. W. Rees, Illinois State Geological Survey. Locations of the samples are given in Appendix II. (Appendix II will appear in a succeeding installment.)

* See *Bull. Amer. Ceram. Soc.*, **14** [3], 116 (1934).

A further significant fact is shown by the analyses, in that the Fe_2O_3, FeO, and MgO content of fraction A of the underclays is decidedly lower than that of the shales. This can be correlated with the absence of yellow and green colored material in fraction A of the underclays.

(4) Dehydration Data Dehydration data for fraction A of five samples of clays and shales occurring beneath coals are given in Fig. 2* and Table IV. Samples Nos. 252 and 268 are from shales below coals, and their data are similar to those of the shales overlying coals (compare Figs. 1 and 2* and Tables II† and IV). The remaining curves in Fig. 2 are distinctive in a higher loss of water at 110°, a gradual small loss from 110 to 400° or 450°, and a sharp, very rapid loss from 400° or 450 to 500°. The dehydration data clearly show the difference in the composition of fraction A of the shales and of the noncalcareous underclays. Moreover, the general shape of the curves for the underclays in Fig. 2 is the same as that for the kaolin group of minerals which, as shown by Ross and Kerr,[20] lose most of their water content between about 400° and 500°. Fraction A of the underclays may, therefore, be inferred to consist mainly of kaolinite. The minor irregularities shown by their curves and their slight variations from those curves of type kaolin minerals are easily accounted for by the presence of small amounts of the sericite-like mineral in the fractions of the samples studied.

(5) Summary of the Mineral Composition of Fraction A The optical, X-ray, chemical, and dehydration data all agree in the identification of kaolinite, the sericite-like mineral, and quartz, as the constituents of fraction A of the noncalcareous underclays. The presence of very fine quartz makes it impossible to determine the position of the kaolin mineral in the kaolinite-anauxite isomorphous series, but it is probably nearest to kaolinite. The data all further indicate that kaolinite is usually the dominant constituent with minor amounts of the other minerals. The optical, chemical, and dehydration information shows that the relative abundance of the latter two minerals is not constant, so that fraction A varies in composition for different underclays from almost pure kaolinite to mixtures with a considerable quantity of the sericite-like mineral. In the latter case, the composition closely approximates that of the shales.

All data show that fraction A of samples Nos. 224, 252, and 268 of shales from below coals has the same composition as fraction A of the shales overlying the coals.

NOTE: Part III will be published in the May issue of *The Bulletin*.

ERRATA: See Part I of this series, March issue, page 117, column 1, lines 37 and 38 should read, "The usual formula given for sericite is $3Al_2O{\cdot}K_2O{\cdot}6SiO_2{\cdot}2H_2O$."

Page 118, footnote 11, "revised" should be substituted for "published."

* See Part I, *Bull. Amer. Ceram. Soc*, **14** [3], 118 (1935).
† *Ibid.*, p. 116.
[20] See footnote 8(*a*), *ibid.*, p. 118.

CHINESE CLAY USED IN PORCELAIN NOT TRUE KAOLIN

Not true kaolin but a hard, jadelike, greenish rock occurring between two beds of slate was used in the manufacture of porcelain by the Chinese according to 19th Century investigators.

At King-te-chen where the Chinese made nearly all their porcelain for almost 3000 years it was discovered that the material from which this porcelain was made was taken from certain strata intercalated between the slate beds already mentioned.

The rock was about as hard as feldspar (inferior grades were softer) and had the greenish color which gave it an appearance similar to jade. The Chinese compared it to this stone.

By stamping, the rock was reduced to a white powdered of which the finest portion was repeatedly separated.

Small molded brick of this material were then delivered to the potters.

Two kinds of the rock were distinguished by the Chinese. Petunt-se (white clay) is the name of one. The place Kaoling (high ridge) was the source of the other which in ancient times was in high repute. Since then it has lost its reputation, but the name "kaoling" still designates the kind of earth formerly prepared from material gathered there.

VARIATIONS IN THE PYROMETRIC CONE EQUIVALENT OF REFRACTORIES AFTER REHEATING AT ELEVATED TEMPERATURES*

By D. A. Dickens,[1] S. S. Cole[2], and M. E. Holmes[3]

Abstract

The pyrometric cone equivalent was obtained on 20 samples each of fire clay and fire brick "as received" and after reheating to 1350°, 1400°, 1450°, 1500°, and 1550°C for various periods of time from 5 to 50 hours. The reheating affected the pyrometric cone equivalent by lowering the values from one to three cones, or, in many instances, raising the value one cone. The greatest variation was found in the samples heated at 1450°, 1500°, and 1550°C for 25 hours. The results indicate that the pyrometric cone equivalent of refractories after reheating to high temperatures will not necessarily be the same as the "as received" value.

I. Introduction

The effect of heating refractories for long periods of time at high temperatures upon the pyrometric cone equivalent has not been reported in the literature. The long heat treatment at high temperatures has been shown to affect the behavior of porcelain bodies and pyrometric cones. The state of equilibrium will not be reached under normal laboratory conditions. It may be possible, however, for a more complete reaction to occur between the mineral components of the refractory by higher temperature heat treatment. If the refractory is partially altered to a glass when the heat treatment is stopped, a lower result in the P. C. E. test may result since the glassy phase is already partially developed. In order to establish whether the long heating would affect the P. C. E. value, a preliminary survey has been made to determine what departure may be anticipated from the "as received" value. Owing to the large number of samples tested, there was no time to obtain two P. C. E. determinations for each heat treatment. The investigation, however, did serve to show that the P. C. E. value will vary depending upon the heat treatment and that further work should be done on the P. C. E. test to eliminate some of the uncontrolled factors.

II. Samples Investigated

The samples were both the fired brick and the raw clays used to make the brick. Twenty different samples of fire brick and raw clay were used in the investigation. The fired brick were selected so that a range in P. C. E. from cones 26 to 36 would be covered in the work.

Samples were obtained from various producing districts. These samples came through the coöperation of Harbison-Walker Refractories Company, Babcock and Wilcox Company, Chicago Retort and Firebrick Company, M. D. Valentine and Brothers Company, and Henry Maurer and Son.

No.	Fire brick	No.	Fire clay
1	Mo. soft clay	31	Pa. flint
2	Mo. hard and soft	32	Ky. flint
3	Mo. hard and soft	33	Ky. soft
4	Mo. hard and soft	34	Ohio flint
5	Chrome	35	Ala. soft
6	Magnesite	36	Mo. flint
7	Ga. and Ala. clay	37	Mo. soft
8	Ala. soft	38	Ohio soft
9	Ohio soft	39	Mo. soft
10	Ohio hard and soft	40	Pa. semiplastic
11	Ky. hard and soft	41	Ala. hard
12	Pa. hard and soft	42	Ga. kaolin
13	Pa. hard and soft	43	Pa. hard
14	Ga. clay	44	Pa. soft
15	Ill. soft	45	Ill. soft
16	Pa. soft	46	Ill. soft
17	Silica	47	Ga. kaolin
18	Pa. soft	48	N. J. plastic
19	N. J. plastic	49	N. J. plastic
20	N. J. plastic	50	N. J. plastic

III. Test Procedure

Spalls were taken from a single brick for all reheating tests, so that the possibility of variations in the samples coming from different brick was eliminated. The clays were ground to pass a 20-mesh screen and molded into cubes for the heat treatment. All samples were heated in a gas-fired furnace of the downdraft type for the

* Presented at the Annual Meeting, American Ceramic Society, Cincinnati, Ohio, February, 1934 (Refractories Division). Received December 22, 1933.

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[1] Candidate for degree of Bachelor of Science.

[2] Graduate Student.

[3] Dean, New York State College of Ceramics, Alfred, N. Y.

various periods of time. The P. C. E. test was carried out according to the specified procedure, A.S.T.M. C24–31, using the furnaces of the Denver Fireclay Company.

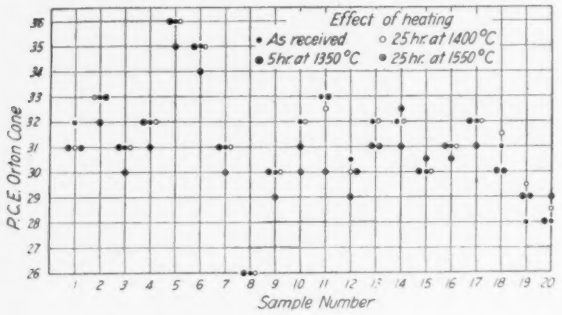

FIG. 1(*a*).

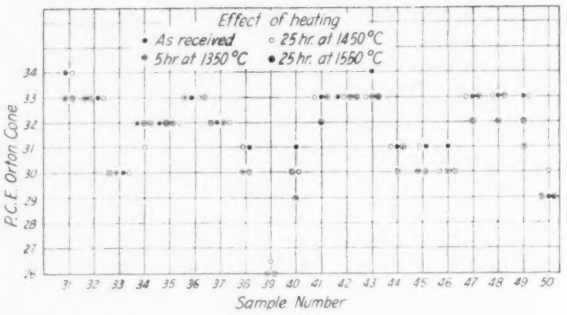

FIG. 1(*b*).

The samples "as received" were tested twice and found to agree. The reheated samples were tested only once.

In all cases except No. 8, there were nine heat

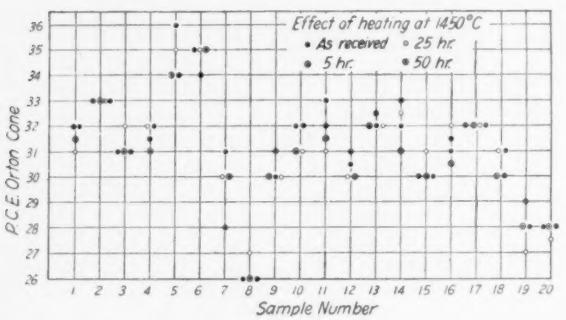

FIG. 2(*a*).

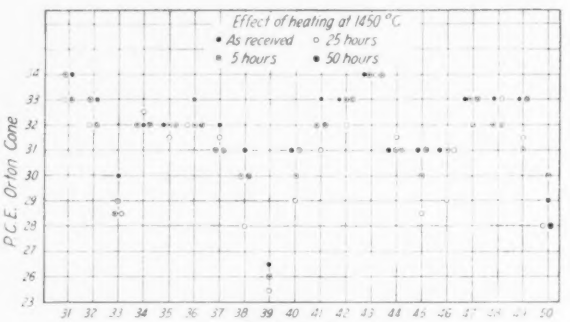

FIG. 2(*b*).

treatments. These samples, together with the duplicate "as received" test, comprised ten tests on each material for comparison with the "as received" test.

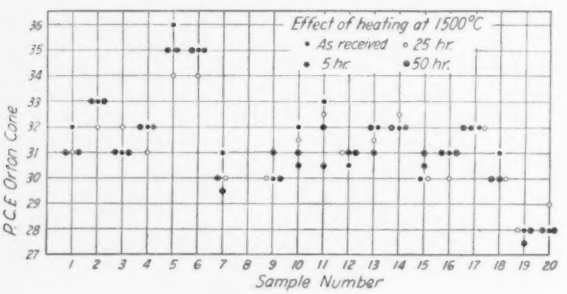

FIG. 3(*a*).

IV. Observations

The reheating of the fire clays and fired refractories caused a lowering of the P. C. E. of 121 samples one cone, of 24 samples two cones, of 4 samples three cones, while 17 samples were found to give one cone higher value than "as received." Previous investigation as to the amount of variation which may occur in P. C. E. determinations has indicated that at least a half cone difference may be anticipated in the test under the same operator.

The amount of variation in the P. C. E. of each sample is given in Table I. From the table the brick which showed the least variation were Nos. 2, 8, and 17, and fire clays Nos. 35 and 42. The fire clays which showed the least variation were of nearly one mineral, *i.e.*, kaolin, although one kaolin showed greater variation. The same effect was not obtained in the case of brick made from Georgia clay. The variation found in the case of chrome brick may have been due to the

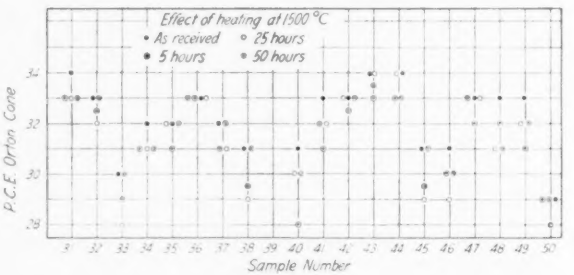

FIG. 3(*b*).

difficulty in obtaining the high temperatures in the P. C. E. test, although fairly good agreement in P. C. E. values was obtained for magnesite brick which had only one cone lower P. C. E.

The variations which occurred in any one heating-test group are reported in Table II. From the data, the heating of the fire brick at 1450°, 1500°, and 1550°C for 25 hours produced the greatest variation in the P. C. E. The

TABLE I

NUMBER OF CASES OF CHANGE IN P. C. E. OF REFRACTORIES FROM P. C. E. "AS RECEIVED," DUE TO REHEATING AT 1350 TO 1550°C FOR 5 TO 50 HOURS

Material No.	No change in P. C. E.	One-half cone different	One cone lower	Two or more cones lower	One cone higher
1	2	1	7		
2	8		2		
3	7		1		2
4	6	1	3		
5	3		4	3	
6	7		3		
7	3		6	1	
8	5				1
9	7		1		2
10	3	1	5	1	
11		4	3	3	
12		9	1		
13	5	2	3		
14	4	3	2		1
15	6	2			2
16	5	3	1		1
17	9		1		
18	2	1	7		
19	4	1	1		4
20	6	2			2
31	3		7		
32	6	1	3		
33	5		4	1	
34	5	1	4		
35	9		1		
36	7		3		
37	5	1	4		
38	3		4	3	
39	1	3	1		
40	2		5	3	
41	3		5	2	
42	8	1	1		
43	5	1	4		
44	6	1	3		
45	4		3	3	
46	3		5	2	
47	7		3		
48	4		4	2	
49	3		3	4	
50	5		3		2

temperature range of 1450 to 1500°C seems to be the most critical for the fire clays. The data indicate that nearly half (43%) of the samples were altered in their observed refractoriness by at least one cone, owing to the heat treatment. Firing for longer periods of time at 1450°C and 1500°C might produce greater variation in the values obtained by this test, although the data here presented do not give conclusive evidence on this point.

It may be concluded from this study that the testing of a refractory after it has been in service may give a result differing from the original value obtained on the brick, even assuming no contamination of the refractory. The longer heat treatment would tend to bring the composition of the refractory into a state of equilibrium and the result would therefore be more indicative of the true refractoriness by the fusion cone method than a test of the unused brick. In like manner, a firing of the fire clays would be the best practice, before subjecting them to the P. C. E. test.

The other viewpoint to be taken is that the P. C. E. test method is not thoroughly reliable. Other data by one of the authors have shown that large variations may enter into the results due to rate of heating in the test, the size of grain of the sample, the angle of setting the cone, the length of the cone above the plaque and the position of the samples in the furnace. The action of the hot, high-velocity gases in the furnace is not prevented in any gas-fired open-flame furnace. The velocity in some furnaces is great enough to cause the cones to swirl at the higher temperatures when softening starts. The use of a carbon-resistance furnace with proper refractory lining to prevent the reducing action of the carbonaceous gases would be a better procedure. A molybdenum furnace can be designed which will attain 1850°C and yet remain gas-tight so that the test chamber is kept under oxidizing conditions if so desired.

TABLE II

NUMBER OF SAMPLES SHOWING VARIATIONS IN P. C. E. AFTER A GIVEN HEAT TREATMENT

Time (hr.)	Temperature (°C)	No variation		Over half cone variation	
		Fire brick	Fire clay	Fire brick	Fire clay
5	1350	11	10	8	8
5	1450	10	9	7	10
5	1500	8	3	8	14
25	1400	14	13	2	5
25	1450	6	2	10	14
25	1500	3	5	10	13
25	1550	2	8	14	10
50	1450	6	10	8	9
50	1500	10	9	7	9

NOTE: Total number of samples at a given temperature was 20 for each class except at 1450°, 1500°, and 1550° for the long periods of heating when there were 19 samples.

V. Conclusions

The reheating of refractories at high temperatures either causes a change in the observed

P. C. E., or the present test procedure is not giving correct results with the equipment used. Reheating at 1450 to 1550°C for 25 hours caused a general lowering in the P. C. E. as compared with the "as received" value.

BIBLIOGRAPHY

(1) H. B. Henderson and J. H. Caldwell, "Increase in Refractoriness in Ceramic Bodies in Interrupted Heat Treatment," *Jour. Amer. Ceram. Soc.*, **11** [11], 795–802 (1928).

(2) S. S. Cole, "Variations in P. C. E. of Silica Cement and Fire Clays," *ibid.*, pp. 854–57.

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EDITORIAL

METHODS OF INDUCING CRYSTALLIZATION*

BY EDWARD W. WASHBURN

ABSTRACT

The general principles underlying all methods of inducing crystallization are formulated and discussed under the headings (*a*) crystallization from the vapor phase, (*b*) crystallization from solution, (*c*) crystallization with the aid of a mineralizer, (*d*) growth of large crystals by slow feeding, and (*e*) crystallization by precipitation. The general conditions which must be observed in each method of crystallizing are described. A list of mineralizers suitable for use with acidic or neutral refractory oxides above 310°C is given.

Introduction

The general methods employed in the laboratory and in industry for obtaining substances in the form of crystals are so well known and so familiar to every one that a presentation or review of these methods might seem superfluous, and indeed such a task will not be attempted here. Instead only a brief review will be given of the underlying principles and the general conditions which must be observed in applying the various classes of methods for producing crystals.

The underlying principles of the methods of inducing a given substance to appear in or to transform into a desired crystalline form in a reasonable time may be briefly summarized by the following statement:

(1) Conditions permitting the necessary freedom of molecular motion should prevail.

(2) The temperature should be below the upper limit of the region of stable existence (under the given conditions) of the form desired and in most cases should be within the region of such stable existence.

(3) Certain types of impurities should be absent.

In most cases all three of these conditions can usually be satisfied simply by cooling the liquid substance below its freezing point and seeding if necessary.[1] In the case of many of the so-called glasses and of the colloidal gels, however, the viscosity of the liquid in this temperature region is so great that the freedom of molecular motion necessary for the production and growth of crystals in a reasonable time is lacking. In other cases the substance, which may have been obtained or produced in an amorphous or microcrystalline condition, can not be rendered fluid by heating because of chemical decomposition. In still other cases the crystalline form desired may not be one which can be obtained directly from the melted material. All such cases frequently require the assistance of special aids to induce or assist the process of crystallization.

Crystallization from the Vapor Phase

Substances, such as iodine, naphthalene, arsenic trioxide, phosphorus pentoxide, etc., which have moderately high vapor pressures at easily attain-

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[1] The technique for the growth of large crystals of metals by this procedure is described by M. F. Hassler, *Rev. Sci. Instruments*, **4**, 656 (1933).

able working temperatures, are frequently purified by sublimation at temperatures below their melting points. In this process crystallization from the vapor phase takes place. The gaseous condition is *par excellence* the condition of free molecular motion, and hence crystallization by this means is an ideal method. Unfortunately, however, it can not be employed with many substances because chemical decomposition occurs before the necessary temperature is attained or because the required temperature is inconveniently high. Large, well-developed crystals are obtained by this method when the temperatures of the evaporating and condensing surfaces are not too far apart. If, however, the vapor pressure at the evaporating surface is very low and the temperature of the condenser is very much lower than that of the evaporating surface, the deposit obtained is frequently amorphous or vitreous. Thus if ice is sublimed at a temperature of about $-50°$ and the vapor is condensed on a target cooled with liquid hydrogen, the deposit obtained is vitreous water, that is, solid, noncrystalline water.

In the case of ceramic materials, the process of sublimation crystallization probably plays an important part in the operation known as sintering. Here the smallest particles and the surfaces with badly distorted lattices[2] evaporate, and the vapor thus produced condenses onto the larger well-developed crystals which therefore grow at the expense of the smaller and distorted ones, the final result usually being a coarsely crystalline aggregate. Examples of large crystals produced by sublimation crystallization are also occasionally found on the walls and roofs of industrial kilns and furnaces.

The kinetic theory of sublimation and condensation at crystal surfaces has been discussed by Langmuir[3] and will therefore not be considered further at this time.

Crystallization from Solution

Substances which are very viscous at their own melting points or which decompose before melting can frequently be crystallized by dissolving them in a suitable solvent and then either evaporating the solvent or cooling the solution below its saturation temperature.

The following conditions must usually be met for successful crystallization by this method.

(1) The solvent employed should be one which when saturated with the substance at the crystallization temperature shall not yield too viscous a solution. In many cases this means that the substance must not be too soluble in the solvent chosen.

(2) The freezing point of the solvent should preferably be so low that solvent crystals will not appear first when the solution is cooled; or, stated in other words, the initial crystallization temperature of the not-too-concentrated solution should be on the solute side of the eutectic, if crystallization is to be effected by cooling. This condition can sometimes be abandoned, however; for example, in cases where the solvent crystals can be readily evaporated out of the eutectic mixture.

(3) If crystals of the original substance are desired, the solvent chosen should not enter into chemical reaction with the dissolved substance in such a manner and to such an extent as to prevent saturation with the original solute molecules. For example, many salts when dissolved in water become hydrated and on cooling the solution, the crystals obtained contain water of hydration. In other cases also the solute may react with the solvent so completely as virtually to destroy or greatly diminish the concentration of the molecular species which it is desired to crystallize. Generally speaking, a purely "physical solution" is best adapted to obtaining a given substance in the form of pure crystals although there are many exceptions to this statement.

(4) If the forces which hold the molecules of the solute in the crystal lattice are weak at ordinary temperatures (*e.g.*, soft, plastic crystals), it is sometimes advantageous to work at very low temperatures in order to strengthen these forces. In such cases the solvent selected should be one which renders this procedure possible.

(5) The substance and the solvent should both be free from impurities of such nature that they are readily adsorbed on the crystal nuclei, since such adsorbed impurities frequently inhibit crystal growth.

(6) To avoid too great a degree of supercooling and in some cases to insure crystallization in the desired crystal form, it is sometimes advantageous to seed the supercooled solution with crystals of the desired type.

[2] *Cf.* L. H. Germer, *Phys. Rev.*, **44**, 1012 (1933).
[3] Irving Langmuir, *Jour. Amer. Chem. Soc.*, **38**, 2250 (1916).

An example of crystallization with the aid of a solvent, which illustrates most of the foregoing principles, is the production of crystals of rubber hydrocarbon. The natural rubber contains impurities of the protein type which inhibit crystal growth and which must therefore be first removed. After purification, the rubber hydrocarbon at ordinary temperatures is a stiff viscous gel or glass which is colorless and very transparent. In order to crystallize it, it is first dissolved in ethyl ether to form a 0.05% solution. Then, since the crystal forces are weak, the solution is first cooled to about −65°C at which temperature the solution retains a high fluidity. After a short time a few crystal nuclei are formed. The temperature is then held at about −58° for several hours in order to allow the crystal nuclei to grow. In this way well-developed spherulites consisting of thin needles radiating from a central point are produced. The melting point of these crystals is 10°C and their optical characteristics have been measured.[4]

Crystallization with the Aid of a Mineralizer

The use of a mineralizer to induce or promote crystallization constitutes a special case of crystallization from solution. Its technique differs from that just described in that the temperature of the system is usually held at a constant value within the region of stable existence of the desired phase and an excess of the substance to be crystallized is maintained in contact with the mineralizer so that the solution is kept saturated therewith. A mineralizer is any fluid liquid which does not react chemically with the substance to be crystallized and in which this substance is at least slightly but not more than moderately soluble. The solution of the substance in contact with the mineralizer is saturated with respect to this substance in the form in which it is used, but it is supersaturated with respect to a more stable crystalline modification of this substance. Consequently, if nuclei of a more stable modification appear in the solution or if the solution be seeded with crystals of the more stable form, crystallization in this form will take place. As a result of this crystallization, the solution now becomes undersaturated with respect to the original substance, some more of this dissolves, and the process continues until eventually all of the original substance has been transformed into the stable crystalline modification.

The function of the mineralizer is to provide a phase of sufficient fluidity to allow that freedom of molecular motion which permits the molecules of the substance to move about and arrange themselves into the stable crystal lattice. A small amount of mineralizer is therefore able in this way to "catalyze" the crystallization or recrystallization of a large amount of material.

Since refractory oxides are relatively nonvolatile substances, mineralizers suitable for use with systems composed of these oxides should not themselves contain any very volatile constituents; otherwise a chemical reaction accompanied by the expulsion of the volatile constituent may take place. For this reason a mixture of alkali carbonates, for example, would not be a suitable mineralizer for use with an acidic refractory oxide. A mixture of alkali chlorides would likewise be unsuitable for use with certain acidic refractory oxides in contact with the atmosphere, since a reaction involving the absorption of oxygen and the expulsion of chlorine may occur. Such a mixture might, however, be utilized in contact with a vacuum or an inert gas. Furthermore, if metathesis or substitution occurs by reaction between the mineralizer and the substance, the products of this reaction must be readily soluble so that equilibrium can be attained without the precipitation or crystallization of a product of the reaction.

Since on cooling to room temperature the system (mineralizer plus transformed substance) usually all solidifies, the mineralizer should preferably be some material which can be readily dissolved out of the mixture by some solvent which does not attack the substance under investigation.

For use with many acidic or neutral oxides and compounds thereof, the vanadates, tungstates and bichromates of the alkali metals, and mixtures of these salts, provide convenient mineralizers for temperatures above 310°C. Some convenient mixtures of this kind are shown in the accompanying table.[5]

In many ceramic bodies development and growth of crystals are promoted by the presence of mineralizers. These mineralizers are usually either traces of low fluxing impurities or small

[4] W. H. Smith, C. P. Saylor, and H. J. Wing, *Bur. Stand. Jour. Research*, **10**, 479 (1933).

[5] The data for most of these mineralizers are taken from the paper of E. N. Bunting, *Bur. Stand. Jour. Research*, **11**, 721 (1933).

amounts of low fluxing materials which have been purposely added. In addition to their possible action as mineralizers, the liquids containing these impurities sometimes solidify to the glassy state when the ware is cooled and serve to bind its particles together so as to produce what is called a vitrified body.

SOME MINERALIZERS ADAPTED FOR USE WITH SYSTEMS COMPOSED OF ONE OR MORE ACIDIC OR NEUTRAL REFRACTORY OXIDES

Components	Weight (%)	Lowest working temperature (°C)
$K_2Cr_2O^7$	75	310
$NaVO_3$	25	
$K_2Cr_2O_7$	100	425
KVO_3	69.8	
$NaVO_3$	12.1	445
$LiVO_3$	8.1	
V_2O_5	10	
KVO_3	77.6	
$NaVO_3$	13.4	461
$LiVO_3$	9.0	
KVO_3	85	480
$NaVO_3$	15	
KVO_3	100	527
$NaVO_3$	100	588
$LiVO_3$	100	599
Na_2WO_4	100	700

Growth of Large Crystals by Slow Feeding

If a single crystal be suspended or supported in its own saturated solution or in its own saturated vapor at constant temperature, it will neither grow nor diminish in size. If, however, the solution (or the vapor) be kept always slightly supersaturated, the crystal will grow continuously in size. Slightly supersaturated conditions can be maintained in various ways. The simplest method is very slow cooling (or in rare cases, heating) of the system, accompanied by adequate stirring. More elaborate methods involve circulation systems in which the solution (or vapor) is circulated through a second vessel where it is given the necessary slight degree of supersaturation and from which it returns again to the vessel containing the suspended crystal. Here the crystal is fed by the excess material in the solution (or vapor) and this, after exhaustion, returns to the supersaturating chamber where its condition of supersaturation is again restored, etc. In simpler types of apparatus the supersaturated solution is simply allowed to fall drop by drop into the thoroughly stirred liquid containing the suspended crystal.

By means of this process of slow feeding, very large crystals can be grown. The process has been successfully employed for growing large crystals of inorganic salts from aqueous solutions and for growing large crystals of metals from their supersaturated vapors. A description of the technique of this process together with a bibliography is given by Hostetter.[6]

Crystallization by Precipitation

When a given substance is precipitated from a solution as a result of a chemical reaction or by a change in the character of the solvent brought about by the addition of another liquid (*e.g.*, alcohol added to an aqueous solution), the general character of the precipitate produced is governed by certain laws or principles which have been formulated by von Veimarn.[7] According to these laws the quantity which is chiefly responsible for the general character of the precipitate obtained is the degree of supersaturation which prevails just before the precipitation takes place. When the supersaturation is very high, the precipitate will be a colloidal gel. When it is very low, the precipitate will consist of a few large crystals.

By working with low degrees of supersaturation and allowing the two reacting solutions to mix slowly by diffusion, a convenient technique for producing large crystals by this method has been developed.[8]

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[6] J. C. Hostetter, *Jour. Wash. Acad. Sci.*, **9**, 85 (1919). *Cf.* footnote 1.

[7] A statement and discussion of these laws is given in the writer's text on Physical Chemistry, 2nd ed., pp. 432–40.

[8] *Cf.* J. Johnston, *Jour. Amer. Chem. Soc.*, **36**, 16 (1914).

ACTIVITIES OF THE SOCIETY

FREDERICK H. RHEAD RECEIVES BINNS MEDAL

INTRODUCTION[1]

In 1925 when Charles Fergus Binns had completed twenty-five years of service as Director of the New York State School of Clayworking and Ceramics, the alumni of that institution, wishing to make a suitable recognition of his achievements, provided for the annual award of a medal bearing his name for distinguished achievement in the field of ceramic art.

[1] From the presentation speech of M. E. Holmes, delivered February 19, 1935, Buffalo, N. Y.

The award is made by a jury consisting of representatives of the American Ceramic Society, the National Terra Cotta Society, The U. S. Potters Association, and the Ceramic Guild of Alfred.

The unanimous choice of the jury for the 1934 medallist was Frederick Hurton Rhead, Art Director, Homer Laughlin China Co., Newell, W. Va. (For biographical sketches of Mr. Rhead see *Jour. Amer. Ceram. Soc.*, **6** [1], 51 (1923), and *Bull. Amer. Ceram. Soc.*, **13** [4], 106 (1934).)

INDUSTRY'S ATTITUDE TOWARD ART TRAINING[2]

By Frederick H. Rhead

When an individual is singled out for public recognition the attempt is often made to estimate the significance of the event and to form a perspective with regard to its relation to human progress in creative development.

I believe that certain groups in this country can and do appreciate and recognize such outstanding figures and influences as that of Charles Fergus Binns, and personages such as he are kept in mind as examples and symbols of unselfish achievement in the arts and sciences.

But I have been wondering whether or not in our haste to achieve the utmost in mechanical and engineering efficiency we have thoughtlessly failed to give due consideration to those elements which concern the development and application of those forces and influences which you are recognizing today.

Attitude of Industry

This is not a criticism of our fine educational organizations or of the product of their labors, but it is a very definite indictment of our industrial attitude, or absence of attitude, with regard to the development and application of creative brain power; a force which is rapidly becoming more essential in connection with the continued successful operation of our mass production industries.

As a contrast to our present industrial attitude with regard to the development of these forces, I cite my own experience.

Attending an English public school I was given, at the age of nine, a year's scholarship in a government art school with the opportunity to extend this privilege at the end of the year. I earned succeeding scholarships and at thirteen was placed on a half-time basis as apprentice in the Brownfield factory. Entering the advanced art classes at the age of fifteen, I was eligible to compete for further scholarships and also for government awards and local prizes.

[2] From the acceptance speech upon presentation of the Medal.

Interest of English Manufacturers

The local manufacturers were not only keenly interested in student activities, but they awarded annual prizes of a nature which, in addition to government awards, made it easily possible for any interested student to acquire fundamental instruction and opportunities for the practical application of acquired knowledge in the factories.

As a result of this interested and active coöperation between the schools, the factories, and the National Science and Art Department, a student acquires a fairly comprehensive education and training in a specialized subject at an age where most of our young people are still in process of planning a career.

Demand for Styled Products

The time is coming when the increasing demand for styled products must be met by native creative forces. At the present time we build factories and machines, but we do not build men and women.

Our manufacturers are splendid organization men and splendid sportsmen. They will gamble in factories and machines and will cheerfully drop a thousand or two at bridge, golf, or other sports, but they have not yet learned to gamble in creative development, the safest gamble of them all.

Today, the schools assume the responsibility. The factory organizations are so out of touch with school activities that while objecting to large importations of foreign ware, they are using foreign labor to produce a stylistic type which should be truly American.

If a country of the size of Great Britain can produce a Wedgwood, a Minton, a Spode, a Doulton, and a score of other national factories, it is surely time that we gave due consideration to the development of our own creative forces, because it is only by such means that we may occupy a position in the world of art and commerce commensurate with the size of our country and the potential possibilities in business.

ART DIVISION MINUTES

REORGANIZATION MEETING HELD IN BUFFALO, N. Y., FEBRUARY 20, 1935

Following a general discussion of the report by L. E. Barringer, concerning the affairs of the Art Division, a committee composed of H. S. Nash, A. E. Baggs, R. G. Cowan, M. M. French, and C. M. Harder, with F. C. Flint attending, was appointed to discuss plans for reorganization. The following recommendations concerning the future activities of the Division were made by this Committee and adopted by the Art Division.

(1) The Art Division will assume the responsibility for four issues of the Society's *Bulletin* to appear quarterly. Two of these numbers are to be devoted to material of direct interest to those concerned with commercial quantity production and two to material of interest to individual or studio potters, teachers of ceramic art, students, and collectors.

In the interest of the latter group, the Annual Robineau Memorial Exhibition will be temporarily accepted as the official exhibition of the Art Division of the American Ceramic Society. For the present, the work shown at this exhibition will be limited to individual designers, students, and teachers of ceramic art. It was also suggested that the annual meeting of this branch of the Art Division be held in connection with the Exhibition.

(2) The Art Division will continue to hold a general session in connection with each Annual Meeting of the Society, the material presented at these sessions to be of broad interest to manufacturers and those concerned with the design of ceramic ware for the market.

(3) Mr. Barringer appointed Frederick H. Rhead to act as chairman of a committee to serve the interests of the Industrial Group. The duty of this Committee, whose additional members are to be appointed by Mr. Rhead, will be to select and edit material for those numbers of *The Bulletin* devoted to the commercial applications of design. This Committee will also assist the chairman of the Division in the preparation of a program for the general session at each Annual Meeting of the Society.

R. Guy Cowan was appointed chairman of a committee to supervise activities in connection with individual or studio production, the teaching of ceramic art, exhibitions, and similar projects. This Committee will select and edit papers for two numbers of *The Bulletin* devoted to this particular field and will supervise arrangements in connection with an annual exhibition of individual designers and decorators.

These committees are to be known as:

(*A*) Committee on Industrial Design and Decoration: F. H. Rhead, *Chairman*

(*B*) Committee on Ceramic Art and Education: R. Guy Cowan, *Chairman*

(4) When it has been demonstrated that the Art Division can satisfactorily issue four numbers of *The Bulletin*, steps will then be taken to secure subscribers for only these four numbers from among the large number of designers, decorators, students, teachers, collectors, curators, and many others throughout the country who are interested exclusively in ceramic products from the artistic and decorative standpoints rather than from the standpoint of production technique.

(5) Charles M. Harder of Alfred agreed to undertake the assembly and compilation of text book material, drawing upon all available scources for the groundwork material desired.—C. M. HARDER, *Secretary*

WHITE WARES COMMITTEES MEET

Minutes of the Meetings of the Industrial Advisory Committee on Whiteware to the Bureau of Standards and the Research Committee of the White Wares Division

Members present at the meeting on February 19, 1935, at Buffalo, N. Y., were as follows: C. W. Parmelee, A. S. Watts, J. W. Whittemore, and Paul E. Cox, representing the colleges; Edward Schramm, G. W. Lapp, Donald Hagar, F. H. Riddle, E. H. Fritz, and R. E. Hanna representing industry; and T. A. Klinefelter, A. S. Creamer, and R. F. Geller, representing the National Bureau of Standards. Absent members were A. V. Bleininger, Perry D. Helser, D. P. Forst, and F. H. Norton. F. P. Hall was chairman.

The chairman gave the functions and purposes of the committees. They are (*a*) to advise with the National Bureau of Standards on matters of whiteware research, (*b*) to avoid needless duplication of research in the various industrial, college, and federal laboratories by acting as a "clearing house" for all those who wish to coöperate, and (*c*) to suggest problems for future research.

The current investigations at the Bureau of Standards were discussed, but no definite recommendations of new problems were submitted. The chairman offered, however, for the consideration of the next chairman, the suggestion that R. E. Hanna, Donald Hagar, Edward Schramm, and F. H. Riddle be appointed as a subcommittee to work with the National Bureau of Standards in outlining a continuation of the study of talc in whiteware. To facilitate this, blueprints of the graphs summarizing the results to date should be furnished the subcommittee.

The chairman also suggested that the incoming Chairman of the White Wares Division of the American Ceramic Society make a survey of all whiteware problems now in active course of investigation in the several laboratories of the country.

The Chairman also recommended that the Committee try to meet in Washington, D. C., in the fall of 1935.

—R. F. GELLER, *Acting Secretary*

Abstracters for *Ceramic Abstracts* Hold Meeting

Problems connected with the preparation and publication of *Ceramic Abstracts*, published by the American Ceramic Society, were discussed at an Abstracters' Meeting held in Buffalo, N. Y., February 20, 1935. The following attended: R. M. King, Louis Navias, and L. J. Trostel of the Publications Committee; B. T. Sweely and H. E. White for Division Editorial Committees, Mary J. Radcliffe, Emily C. Van Schoick, and Ross C. Purdy representing the Editorial Office, and J. B. Austin and R. A. Heindl, abstracters.

Many of the twenty-eight abstracters were unable to attend. Alexis Pincus and H. E. Simpson attended the meeting as visitors.

Discussion

Availability of journals, extent of abstracts of English and foreign language articles, scope and content of an abstract, scrutiny of the fourteen subdivisions of *Ceramic Abstracts*, and review of Patent Abstracts were discussed.

(1) *English vs. Foreign Language Abstracts*

It was decided that articles appearing in the English language should be given less abstract space than articles in foreign languages because the original English publications are more generally available in this country.

(2) *Availability of Articles*

Less readily available journals should be more thoroughly abstracted than the readily available journals.

(3) *Directory of Libraries*

J. B. Austin and R. H. H. Pierce, Jr., offered to prepare in the next year a Directory of Libraries showing where journals which we abstract are to be obtained. This compilation should help abstracters to determine which journals are readily available. This is a self-appointed task.

(4) *Abrasive-Using Machinery and Devices*

It was suggested that no abstracts on abrasive-using machinery and devices be printed. The few essential devices could be listed under the heading of equipment.

(5) *Cements, Lime, and Plasters*

The advisability of carrying an abstract section in this field was considered. Several ceramic schools are including courses in these fields of work. It was suggested that the title of this subdivision be made: "Lime, Plasters, and Cements" and that practical articles on cements be not abstracted.

(6) *Anonymous Articles*

Practically no anonymous articles should be abstracted. Some government bureau publications and some articles of importance are issued with no author names given. These should be scrutinized carefully before abstracting.

(7) *Equilibrium Diagrams*

The publication of equilibrium diagrams was considered desirable. It was suggested that the Fellows consider financing the further publications of equilibrium diagram under separate cover. If the cuts are made soon after publication of the original articles, the same cuts could be used for the *Abstracts*.

(8) *Cross-References*

Consideration should be given to the possibility of using short cross-references as practiced by *Chemical Abstracts*.

(9) *Patent Abstracts*

Foreign patents should be given more space than American patents.

(10) *Ceramic Abstract Editors*

Several abstracters feel that each Division of the Society should have an abstract editor to decide whether an article is worth abstracting and to maintain a high level of abstracting in his field.

Several Divisions should try out this idea. The Executive Committee of the Enamel Division is considering such a plan.

(11) *New Abstracters*

Alexis Pincus and Harold E. Simpson have been added to the staff of abstracters.—LOUIS NAVIAS, *Chairman* and *Secretary pro-tem.*

SHUFFLING ALONG

For thirty-six years the American Ceramic Society has been devoted to the promotion of the arts, science, and technology of ceramic-ware production: clay, glass, and glass enameled production.

This was the first such organization in the world and it is the only one in America today. Since this Society was founded, similar societies have been established in the several nations of the world. The importance and value of such coöperative enterprises have a world-wide recognition by ceramic-ware producers.

The economic depression and the high cost of code preparation and compliance have greatly reduced the financial capabilities of this Society. These circumstances, however, have not decreased the alertness of the officers and committeemen in prosecuting the objectives of the Society most effectively. The Annual Meetings during the depression have continued in their richness of technical programs and in the attendance of delegates at the Meetings.

The value of research and education to the industries has been so thoroughly proved that there has been a growing interest in the technical literature and the Annual Meetings during these years of economic depression. Many lines of industries have similar organizations devoted exclusively to their arts, science, and technology.

The 1934 Committee on Membership and Advertising, under the inspired and vital leadership of Richard B.

Carothers, stemmed the shrinkage in membership and advertising support of this Society and its publications. The enthusiasm shown at the Annual Meeting in Buffalo last February was inspiring.

During the coming year under the leadership of Grant S. Diamond as Chairman of the Membership and Advertising Committee and of J. M. McKinley as President of the Society, it is anticipated that this organization will regain a large portion of the support which it has had in the past. The following is our 1935 record up to February 28, 1935.

	Paid		
	Personal	Corporation	Those of 1934 unpaid 1935
Dec. 31, 1934	1239	167	302 personal
1935 up to Feb. 28	1154	142	24 corporations

	New Members	Deferred subscriptions and current sales	Total circulation
Dec. 31, 1934	181	516	1922
1935 up to Feb. 28	67 personal 6 corporations	600	1896

J. M. McKinley and G. S. Diamond must depend upon the individual members personally soliciting membership support of ceramic persons and corporations.

NEW MEMBERS

CORPORATION

Solvay Process Co., 61 Broadway, New York, N. Y.

PERSONAL

Austin, James Bliss, Research Laboratory, U. S. Steel Corp., Lincoln Highway, Kearny, N. J.; physical chemist.

Eagle, J. Eugene, 2827 Bergman St., Pittsburgh, Pa.; ceramic engineer, The Vitro Mfg. Co.

Robinson, Robert Roger, Pittsburgh Rd., Zelienople, Pa.; engineer, Robinson Ventilating Co.

Slaughter, James A., 1900 Main St., Elwood, Ind.; ceramic engineer, Pittsburgh Plate Glass Co., Works No. 7.

STUDENT

Ellefson, Bennett S., Pennsylvania State College, State College, Pa.

Kunzman, Edward E., N. Y. State College of Ceramics, Alfred, N. Y.

Membership Workers' Record

CORPORATION			
Office	1		
PERSONAL		**STUDENT**	
C. S. Linder	1	M. E. Holmes	1
R. B. Sosman	1	F. J. Williams	1
A. J. Strod	1		2
H. E. White	1	Grand Total	7
	4		

ROSTER CHANGES DURING MARCH

Personal

Armstrong, Frederick M., Johns-Manville Co., Manville, N. J. (Champaign, Ill.)

Berns, Milton H., Electro Refractories & Alloys Corp., 59 Arthur Ave., Blasdell, N. Y. (Farnham, N. Y.)

Blanchard, James R., 144 E. Main St., Lancaster, Ohio. (Columbus, Ohio.)

Blume, Arthur J., 228 Marne Ave., Haddonfield, N. J. (Chatsworth, N. J.)

Brownlee, W. K., Laclede-Christy Clay Products Co., Toledo, Ohio. (Buckeye Clay Pot Co.)

Canfield, Ruth E., 265 Henry St., Henry Street Settlement, New York, N. Y. (Friendship, N. Y.)

Delangre, M. Georges, 8 avenue du General Horne, Valenciennes (Nord) France. (Beuvrages Nord France.)

Edward, Oran K., 4125 N. Mississippi Ave., Portland, Ore. (160 Mill St.)

Emery, Walter, Hawarden, Hurlford, Ayrshire, Scotland (corrected from England).

Ferguson, Robert F., Hazel-Atlas Glass Co., Zanesville, Ohio. (151 S. Sixth St.)

Gautsch, Murray C., Metal & Thermit Corp., Carteret, N. J. (Baltimore Enamel & Novelty Co., Baltimore, Md.)

Grimes, G. J., Florence Stove Co., 2207 W. Station St., Kankakee, Ill. (Detroit, Mich.)

Hults, E. A., % The Mathieson Alkali Works, Inc., 60 E. 42nd St., New York, N. Y. (Saltville, Va.)

Lee, Robert E., 214 Adams St., Jefferson City, Mo. (R. R. No. 3, Box 23.)

McCollom, Perry C., General Refractories Co., Baltimore, Md. (Athens, Texas.)

McHose, M. M., % L. H. McHose, Inc., P. O. Box 345, Perth Amboy, N. J. (North Plainfield, N. J.)

Montgomery, Earl T., Montgomery Porcelain Products Co., Franklin, Ohio. (Smith & Stone, Ltd., Georgetown, Ont.)

Mueller, Kurt, Davidson Enamel Products Co., Clyde, Ohio. (Wapakoneta, Ohio.)

Reitz, Adolph G., Oakfield, N. Y. (Bolivar, N. Y.)

Smith, Hillard A., 225 Kearny Ave., Perth Amboy, N. J. (Palmerton, Pa.)

Trees, Jack E., 161 Chalmers St., Detroit, Mich. (1130 Holcomb St.)

Underwood, C. A., 61 Salisbury St., Winchester, Mass. (3 Central St.)

CERAMIC WARE COLLECTION AT EXECUTIVE OFFICE

The Society has accumulated what many have pleased to say is quite an unusual and an extraordinarily fine exhibit of ceramic products of all sorts. The Society is proud of its growing library and growing museum.

There have been four notable additions to the exhibit since we last reported:

(1) Porcelain Products, Incorporated, Findlay, Ohio, the intricate electric insulators and the glazed wall tile.

(2) The Pyrex-brand glass sword made by the Corning Glass Works and presented to Colonel Ross C. Purdy at the last Annual Meeting, beautifully engraved and made to conform in shape and size with the regulation sword.

(3) A vase presented by Miss Elsie Binns, made by her father, Charles Fergus Binns, in 1932.

(4) Porcelain toys and figurines from Benares Hindu University, India.

The exhibit at the office is viewed by many individuals and groups. The Society would welcome contributions of modern products and historical specimens.

OFFICERS AND COMMITTEE APPOINTMENTS FOR 1935-1936

President: J. M. McKinley, North American Refractories Co., Cleveland, Ohio.
Vice-President: Francis C. Flint, Hazel-Atlas Glass Co., Washington, Pa.
Treasurer: H. B. Henderson, H. B. Henderson Co., New Brighton, Pa.
General Secretary and Editor: Ross C. Purdy, 2525 North High St., Columbus, Ohio.
Past President: W. Keith McAfee, Universal Sanitary Mfg. Co., New Castle, Pa.
Past President: J. C. Hostetter, Corning Glass Works, Corning, N. Y.

Trustees of Industrial Divisions*

Art: F. H. Rhead, Homer Laughlin China Co., Newell, W. Va. (1937).
Enamel: W. C. Lindemann, Lindemann & Hoverson Co., Milwaukee, Wis. (1937).
Glass: J. T. Littleton, Corning Glass Works, Corning, N. Y. (1938).
Materials & Equipment: V. V. Kelsey, Consolidated Feldspar Corp., Trenton, N. J. (1936).
Refractories: R. B. Sosman, United States Steel Corp., Kearny, N. J. (1937).
Structural Clay Products: R. B. Keplinger, Metropolitan Paving Brick Co., Canton, Ohio (1936).
Terra Cotta: R. L. Clare, Federal Seaboard Terra Cotta Co., Woodbridge, N. J. (1936).
White Wares: Perry D. Helser, General Ceramics Co., New York, N. Y. (1938).

* Date of expiration of term in parentheses.

Officers of the Fellows

Dean: F. H. Riddle, Champion Spark Plug Co., Detroit, Mich.
Associate Dean: A. S. Watts, Ohio State Univ., Columbus, Ohio.
Secretary: G. H. Brown, Rutgers Univ., New Brunswick, N. J.

Standing Committee Appointments

Research: Five members to serve permanently on a rotating basis as advisory head of the Committee. (Division representatives will be named on the Division chart.*)
Data: William L. Fabianic, Owens-Illinois Glass Co., Alton, Ill.
Standards: Arthur S. Watts, Ohio State Univ., Columbus, Ohio.
Education: Harold E. White, Lava Crucible Co., Zelienople, Pa.
Geology: W. M. Weigel, Missouri-Pacific Bldg., St. Louis, Mo., *Chairman;* Hewitt Wilson, Univ. of Washington, Seattle, Wash.; J. W. Whittemore, Va. Polytechnic Inst., Blacksburg, Va.; J. E. Lamar, University of Illinois, Urbana, Ill.; H. Ries, Dept. of Geology, Cornell Univ., Ithaca, N. Y.
Rules: Lawrence E. Barringer, General Electric Co., Schenectady, N. Y.
Membership: Grant S. Diamond, Electro Refractories and Alloys Corp., Buffalo, N. Y.
Publications: Louis Navias, *Chairman,* General Electric Co., Schenectady, N. Y.; L. J. Trostel, General Refractories Co., Baltimore, Md.; M. F. Beecher, Norton Co., Worcester, Mass.; R. M. King, Ohio State Univ., Columbus, Ohio.
Sections and Division: Emerson P. Poste, Chattanooga, Tenn.
Management: R. B. Keplinger, Metropolitan Paving Brick Co., Canton, Ohio.
Statistics: Thomas N. Kurtz, North American Refractories Co., Mt. Union, Pa.

*To be published in *The Bulletin* for May.

Appointed Representatives

American Assn. for Advancement of Science: G. S. Fulcher, Corhart Refractories Co., Louisville, Ky.
Orton Ceramic Foundation Trustee: J. M. McKinley (elected for term of three years).
Natl. Research Council, Div. of Chemistry and Chemical Technology: J. C. Hostetter.
Natl. Research Council, Div. of Geology and Geography: R. C. Purdy.
International Union of Chemistry: Alexander Silverman, Univ. of Pittsburgh, Pittsburgh, Pa.
International Congress of Glass and Ceramics: J. C. Hostetter.
International Assn. for Testing Materials: Arthur S. Watts.
American Standards Assn., Comm. on Safety Code, Safety Glass: J. T. Littleton, Corning Glass Works, Corning, N. Y.; Wilbur Brown, Libbey-Owens-Ford Glass Co., Charleston, W. Va.
American Standards Assn., Classification of Coals: W. H. Fulweiler, United Gas Improvement Co., Philadelphia, Pa.
A.S.T.M., Comm. A-1: Homer F. Staley, Metal & Thermit Corp., New York, N. Y.
A.S.T.M., Comm. on Gaseous Fuels: A. W. Gauger, Penn. State College, State College, Pa.; Walter W. Oakley, Corning Glass Works, Corning, N. Y.; Clifford H. Parmelee, Onondaga Pottery Co., Syracuse, N. Y.
American Society of Mechanical Engineers, Process Div.: W. Keith McAfee.
American Society of Mechanical Engineers, Petroleum Div.: H. R. Straight, Adel Clay Products Co., Adel, Iowa.
Glass Division, Illuminating Society, and Illuminating Glassware Guild: H. H. Blau, Macbeth-Evans Glass Co., Charleroi, Pa.; R. A. Miller, Pittsburgh Plate Glass Co., Pittsburgh, Pa.

LOCAL SECTION NEWS

Central Ohio Section Meets

The March meeting of the Central Ohio Section, held at Ohio State University, March 5, was sponsored jointly by the Local Section and the Ohio State University Student Branch. About sixty persons were present.

George Brainerd, member of the University of Pennsylvania Persian Expedition, was speaker. For excerpts from his talk see *The Bulletin,* this issue, p. 156. He told of the expedition's activities in North Persia, particularly stressing the ceramic findings.

Specimens of ceramic art recovered from ruins dating from 6000 B.C. to modern times were exhibited at the meeting. The earliest specimens were very crude but appeared to have been well fired.

Later ware showed the influence of Egyptian and Mesopotamian cultures, and following the conquest of Alexander the Great, the Greek influence was apparent.

Dating from approximately 1000 A.D., copper luster glazes beautifully preserved were found. There was also evidence of commerce with China following the conquests of Genghis Khan and other Mongol conquerors. One especially good specimen of Ming "shadow ware" found in the ruins dating approximately 1200 A.D. was shown by Mr. Brainerd.

The talk was an example of the policy of this Section to intersperse the technical talks with those of a cultural nature.—J. O. EVERHART

Pittsburgh Section Meets

Fulton B. Flick spoke on "Patents in Ceramics" at the meeting of the Pittsburgh Local Section held March 12, 1935, at Mellon Institute. Thirty members and guests attended.

The speaker covered many angles of the patent field and brought out many unknown facts connected with taking out a patent.

He also reviewed some of the earlier patents granted in this country. The address was followed by one of the best discussions this Section has had for some time.

—EARL C. PETRIE, *Secretary*

ILLINOIS STUDENT BRANCH ACTIVE

The Student Branch of the American Ceramic Society at the University of Illinois held its Annual Smoker in October. Forty-one students joined the Branch. During the first semester a technical talk by R. E. McNamee of General Refractories Co. and an illustrated lecture by C. W. Parmelee were heard.

Officers for the year are as follows: W. S. Debenham, *President*; J. C. Bell, *Vice-President*; and M. Voigt, *Secretary-Treasurer*.

The Branch has planned the Ceramic Exhibit, part of the Engineering College Exhibit held April 13, 1935. Enameled University of Illinois souvenirs have been prepared. R. K. Hursh and C. L. Thompson were faculty advisors for the project.

Six seniors attended the Annual Meeting of the Society in Buffalo and then inspected several plants in Pennsylvania and Ohio on the return trip. Their reports were heard at the March meeting of the Branch.

Plans for the Annual Pig Roast, which winds up the year's activities, will be made at this meeting.

H. G. Wolfram, of Porcelain Enamel Mfg. Co., will be the speaker for this event.—W. S. DEBENHAM

AN ERRATUM

Our Apologies to the Publicity Committee, Buffalo Meeting

The names of the Publicity Committee of the Local Committee for the Buffalo Meeting were inadvertently omitted from the list published in *The Bulletin* for March, p. 121. F. D. Bowman of the Carborundum Company, Niagara Falls, N. Y., was chairman of this committee. Mr. Bowman submitted stories on the Annual Meeting which were published in the December *Bulletin*, pp. 344–45 and in the January *Bulletin*, pp. 26–29. He also made arrangements with those persons who took part in the radio talks preceding the Meeting. It is with profound appreciation that the Editor makes this acknowledgment of the work of this committee, headed by Mr. Bowman.

CHARLES FERGUS BINNS MEMORIAL
New York State College of Ceramics
Dedication of Binns Hall
June 7, 1935.

IOWA STATE COLLEGE STUDENT BRANCH HISTORY GIVEN*

When I came to Iowa State College in 1920 the Department of Ceramic Engineering had about a half-dozen students. The evening meetings of the Student Branch of the American Ceramic Society were attended by the two men of the faculty at that time and the three officers. These officers were using the organization to make themselves eligible to the Engineering Council.

The enrolment reached sixty in 1929, but has since fallen off as have other departments of this campus during the depression.

Fraternity meetings and other evening events made it impossible to have attendance for any sort of night meeting on this campus. But the catalog called for attendance of all students after the freshman year at a so-called seminar. No credit was given for this. Every device was used by the student body to avoid attendance.

I made this seminar into a Student Branch of the American Ceramic Society and required all students except freshman to attend. An hour in the regular schedule of the day is set for this meeting.

Students prepare and deliver talks at these meetings. Special moving picture films or lantern slides are used to illustrate some of the talks. Sometimes faculty men outside the department speak.

Although from the smallest department on the campus, my students have taken once each the sweepstakes prize for a float, the second sweepstakes prize, and first prize in the engineering division in the parade held during Veishea, the annual spring all-campus festival.

For the open-house show held during this festival our department has contributed many novel features. Because of the success of this department in staging a high-class show each year, the Veishea Committee this year allotted us twice as much money as was allotted any other department.

We have an active Student Branch here and, under the circumstances, required attendance during the regular schedule of the day is the most satisfactory solution to the problem.

Secretary Purdy has frequently stated that very few graduates of the various institutions were members of the Society. I believe that our students here look forward to active participation in the affairs of the Society as one of the great privileges due them from their profession. The Trustees and Publications Committee should understand how much the boys desire to see their student problem reports in the *Journal*, even though the trade journals sometimes pay space rates for them.

With the return of better business conditions, the Society might well consider publication of many of these reports because of the potential value of the boys as members of our Society.—PAUL E. COX, *Head of Department*

*Received March 1, 1935.

WILLIAM H. CRUME

William H. Crume, president of the Crume Brick Co., Dayton, Ohio, died March 8, 1935, at Dayton. Mr. Crume was born in Dayton, February 10, 1876, of pioneer residents of the vicinity and spent his boyhood there.

After studying at the Michigan Military Academy and the Stevens Institute of Technology, Hoboken, N. J., he obtained work with a chemical concern and later with a brick company, in Moline, Ill.

In 1909 he returned to Dayton and organized the Crume Brick Co., which he still headed at his death.

Mr. Crume was a member of the American Ceramic Society from 1919 until 1932.

NOTES AND NEWS

YENCHING UNIVERSITY ESTABLISHES CERAMIC RESEARCH LABORATORY

Using a research grant from the British Boxer Indemnity Board at Nanking, E. O. Wilson, head of the Chemistry Department of Yenching University located in Peiping West, China, has established a Ceramic Research Laboratory in his department.

C. Y. Lin and a graduate student have been employed on the research work in this laboratory since September, 1934.

A few chemical analyses of clay samples have been made and some physical properties such as volume shrinkage, linear shrinkage, and water of plasticity of fifteen kinds of clays have been determined. The clay samples have been mostly from the Pencheng district of the Honan Province, the ceramic center of North China. Further work will be undertaken as fast as the necessary equipment becomes available.

C. C. Lin, adviser for the laboratory, graduated from Ohio State University in 1918. E. O. Wilson, now doing research work at Massachusetts Institute of Technology is expected to return to Yenching University in September, 1935. The China Foundation for the Promotion of Culture and Education has made C. Y. Lin a research grant of $500 for an investigation of glazed roofing tile. This work is now under way.—C. Y. LIN

MASSACHUSETTS INSTITUTE OF TECHNOLOGY OFFERS ADVANCED DEGREES IN CERAMICS

The notable contributions of ceramics in industrial processes and the opportunities for applying modern knowledge in chemistry and physics for future developments have led to the establishment of advanced degrees in ceramics at the Massachusetts Institute of Technology, Cambridge, Mass.

Contributions of Institute's Laboratories

The Institute's course in ceramics now offers advanced work leading to the degrees of master and doctor of science. Among the contributions from these ceramics laboratories are asbestos shingles, kaolin brick, asbestos board, insulating refractories, and machines for molding silica brick. Extensive research has been carried on concerning the nature of plastic phenomena and the mechanism of color in the form of new glazes and materials. Quick methods of firing and forming, fresh decorative processes, and the adaptation of new materials to ceramic purposes, are now being studied.

The Geological Society of America has presented the Institute with a grant from the Penrose Fund for a study of the synthesis of clays. This work will be under the direction of Frederick H. Norton, in charge of instruction and research in ceramics in the department of mining and metallurgy.

Museum Collection

A notable museum of historic and contemporary pottery and glassware, largely the work of native New England craftsmen, also has been assembled in the Institute's ceramic division. The collection contains a number of fine period pieces and is of great value in tracing types of decoration and the general progress of the art.

The ceramics course in Technology emphasizes initiative, resourcefulness, and creative ability, rather than the study of details which can better be acquired in the manufacturing plant. The effectiveness of such training is evidenced by the fact that the demand for Technology graduates in this field has invariably exceeded the number of men available.

Requirements for Doctorate Candidates

Candidates for the new doctorate in ceramics must have, in addition to strictly ceramic subjects, a thorough knowledge of physics, chemistry, physical chemistry, combustion, furnace design, X-ray and crystal structure, drying, heat measurements, and colloids. The degree of master of science will be awarded to students who pass with high standing a required number of advanced subjects. In awarding either degree, major emphasis will be placed on an original and convincing thesis.

Among the advanced special studies offered are optical ceramics, the investigation of products and materials with the petrographic microscope; fundamental ceramic processes, a detailed study of physical and chemical mechanism; the physical properties of ceramic products, dealing with properties of finished ware, methods of testing, and control of quality; and special problems, in which the student may choose his own topic of research.

CERAMIC EDUCATORS ORGANIZE ASSOCIATION

The Association of Ceramic Educators, organized at Buffalo, N. Y., February 17, 1935, at a conference of the heads of all departments of ceramic engineering, technology, and art in the universities of the United States and Canada, has announced the following objectives: (1) to promote ceramic education, (2) to improve teaching facilities, and (3) to standardize fundamental curricula in the various branches of ceramic instruction.

Membership is limited to professors, associate professors, and assistant professors in ceramic departments.

The association's activities are limited to development and promotion.

Officers and Committees

Arthur S. Watts, Ohio State Univ., Columbus, Ohio, *President*, and A. F. Greaves-Walker, University of North Carolina, Raleigh, N. C., *Secretary*, were elected.

Committees to consider the following subjects were chosen:

Syllabi and Texts for Student Use: C. W. Parmelee, Univ. of Illinois, *Chairman;* T. N. McVay, Univ. of Alabama; R. J. Montgomery, Univ. of Toronto; Hewitt Wilson, Univ. of Washington; and J. W. Whittemore, Virginia Polytechnic Inst.

Essentials of Ceramic Curricula: M. E. Holmes, N. Y. State College of Ceramics, *Chairman;* A. F. Greaves-Walker, Univ. of North Carolina; F. H. Norton, Mass. Inst. of Technology; N. W. Taylor, Penn State College; and A. S. Watts, Ohio State Univ.

Publicity for Ceramic Education: G. H. Brown, Rutgers Univ., *Chairman;* A. E. Baggs, Ohio State Univ.; C. M. Dodd, Missouri School of Mines; P. E. Cox, Iowa State College; and A. V. Henry, Georgia School of Technology.

—A. S. W.

COMMITTEE C-8, A.S.T.M. MEETS AT BUFFALO

The 51st meeting of Committee C-8 on Refractories of A.S.T.M. was held in conjunction with the Annual Meeting of the American Ceramic Society in Buffalo, New York, on February 19. The Committee has recommended that the Standard Pyrometric Cone Company endeavor to establish a new series of test cones with uniform temperature intervals. Definitions for insulating fire brick; insulating brick; calcining, as applied to refractories; firing, as applied to refractories; grog fireclay mortar; and super-duty fire clay brick were presented.

A new A.S.T.M. Book of Standards on refractories is now available for distribution. The Committee is to coöperate with the International Standards Association Committee on Refractories. An interesting report was presented by T. A. Klinefelter on the possibility of the use of the petrographic microscope in the analysis of refractories.

The Committee on Load reported on research done on the development of a new load-test furnace in which the loading will be direct instead of by a lever.

The officers of Committee C-8 are R. A. Heindl, National Bureau of Standards, *Chairman;* E. H. Van Schoick, Chicago Retort and Fire Brick Co., *Vice-Chairman;* and C. E. Bales, Ironton Fire Brick Co., *Secretary.*

MARCH 6, 1935
IRONTON, OHIO

Iowa Clay Products Short Course Attended by 40

In spite of the ice-covered highways and intense cold the registered attendance at the Iowa Clay Products Short Course held at Iowa State College, January 23 to 25 was more than forty.

Additions to the program published in *The Bulletin*, pp. 45–46 (January, 1935) are as follows: (1) an impromptu talk on abrasive surfaces by Jack Mayer of Bethlehem Steel Co., and (2) a moving picture, "Reinforced Brick Construction" which was furnished by the Brick Manufacturers Assn.—D. A. MOULTON

U. S. Potter's Association Names Officers for 1935

The following were elected to office in the U. S. Potter's Association at a meeting held December 5, 1934: *President*, Robert E. Boyce, Harker Pottery Co., Newell, W. Va.; *First Vice-President*, Richard H. Pass, Onondaga Pottery, Syracuse, N. Y.; *Second Vice-President*, Frank C. George, W. S. George Pottery Co., Canonsburg, Pa.; *Third Vice-President*, Arthur A. Wells, Homer Laughlin China Co., Newell, W. Va.; *Secretary-Treasurer*, Charles F. Goodwin, East Liverpool, Ohio.

D. G. Albright, Limoges Pottery Co., heads the *Manufacturers Cost Committee;* Gale Turnbull, Sebring Pottery Co., the *Art and Design Committee;* William Pomeroy, East Liverpool, Ohio, the *Membership Committee;* D. William Scammell, Scammell China Co., the *Reception Committee;* and John Wendt, Crown Pottery, the *Kiln and Fuel Committee.*

American Foundrymen's Association to Meet at Toronto in 1935

The American Foundrymen's Association will hold its 1935 convention at Toronto, the largest foundry center in the Dominion of Canada, August 19 to 23, inclusive. The Royal York Hotel will be headquarters for the convention.

This meeting will be held without an exhibit and will be patterned after the successful technical meeting held in Chicago in 1927. The entire program will be devoted to technical sessions, shop courses, round table discussions, committee meetings, plant visits, and social functions.

Canadian National Exposition

The closing of the convention on Friday noon will coincide with the opening of the Canadian National Exposition which is held each summer. Special features of this internationally known fair are to be provided for the visiting foundrymen on Friday afternoon and evening. These will be announced later.

STANDARDS ON REFRACTORY MATERIALS PUBLISHED

This publication includes the twenty-one specifications, test methods, and definitions standardized by the A.S.T.M. through the work of its Committee C-8 on Refractories, the revised and simplified Manual on Interpretation of Refractory Test Data, detailed information on the standard samples of type refractory materials, and reports of industrial surveys showing the service conditions of refractories in outstanding consuming industries.

The specifications cover clay fire brick for various uses, refractories for the construction of incinerators, ground fire clay, and quicklime and hydrated lime for the manufacture of silica brick.

The standard methods of testing include porosity and volume change, particle size of ground materials, panel test for resistance to thermal and structural spalling, permanent linear change, test under load at high temperature, softening point, high-temperature heat insulation, and chemical analysis of refractory materials.

The composition of a series of standard samples of refractory materials, developed in coöperation with the National Bureau of Standards and other laboratories, is given in tabular form.

Comprehensive surveys have been made of conditions under which refractories are used in open-hearth practice, malleable iron industry, copper industry, lead industry, and by-product coke ovens.

Copies of this publication comprising 143 pages, in heavy paper cover, can be obtained from A.S.T.M. Headquarters, 260 S. Broad St., Philadelphia, at $1.00 per copy. Special prices are in effect on orders for ten or more copies.

INTERNATIONAL CONGRESS ON GLASS AND CERAMICS PUBLISHES TRANSACTIONS

The date of the First International Congress on Glass and Ceramics, held in Milan, Italy, September 16 to 25, 1933, will undoubtedly be of historical importance to the glass and ceramic industries throughout the world, because it marks the foundation of international coöperative work in these fields.

The Transactions of this Congress, published in Milan in 1934, indicate that what may be considered as an experiment in international coöperation was most successful. Of the three hundred members attending the Congress one hundred fifty came from various foreign countries. Outstanding leaders of the ceramic industries of the world met in person here. This gave an opportunity for the exchange and interchange of scientific and technical ideas as well as leading to better understanding between nations and tending to bring all nations to a higher standard of culture.

These same ideas were expressed by many of those who addressed the Congress.

The Congress formed a committee to organize the next International Congress in London in 1936. The members of this committee are as follows: J.W. Mellor and W. E. S. Turner, England; Louis Desmarquest and A. Olivier, France; Gustav Keppeler and Heinrich Maurach, Germany; Beniamino Douzelli and Luciano Scotti, Italy; J. A. De Artigas, Spain; and J. C. Hostetter, United States of America.

An International Commission for promoting glass research was also organized. This has been reported in *The Bulletin*, p. 205 (August, 1934). The Glass Division of the America Ceramic Society is coöperating with this Commission in the investigation of the chemical durability of glass as reported in *The Bulletin*, pp. 319–320 (November, 1934).

The Transactions of this Congress, "Atti del 1° Congresso Internazionale del Vetri e della Ceramica," make up a volume of international importance. Seventy-two papers were presented at the Congress, many of them by ceramists and glass technologists who are also members of the American Ceramic Society.

Of the thirty-six papers on ceramic subjects, fifteen were from Italy, nine from France, five from Germany, three from U.S.S.R., two from England, and one from Czechoslovakia.

Eleven of the thirty-six papers on glass subjects were from England, ten from Italy, five from Germany, three from France, two each from U.S.S.R. and Czechoslovakia, and one each from Spain, the United States of America, and Belgium.

Scientists and technologists contributing papers to the Congress who also belong to the American Ceramic Society are as follows: Pierre Bremond, Peter P. Budnikoff, F. Eckert, Kurd Endell, Bernard Long, S. I. Perkal, Walter James Rees, A. E. Vickers, J. A. Sugden, J. A. De Artigas, M. A. Besborodov, Alexander Silverman, Gustav Keppeler, I. I. Kitaigorodskiĭ, John B. Murgatroyd, and W. E. S. Turner.

Although not all the papers were read at the Congress and not all are reproduced in full in the Transactions, much material of international importance has been presented.

Historically the work is of great importance, as marking a new period in the history of ceramics.—SELICK I. PERKAL.

A.S.T.M. Annual Meeting to Be Held June 24 to 28

The thirty-eighth annual meeting of the American Society for Testing Materials will be held at the Book-Cadillac Hotel, Detroit, Michigan, June 24 to 28, 1935.

—R. E. HESS, *Asst. Secretary*

Norton to Tour Scandinavian Countries in June

Frederick H. Norton of the Massachusetts Institute of Technology will join members of the Ceramic Society [England], the Institute of Clayworkers, the British Pottery Manufacturers' Federation, and the National Federation of Clay Industries in a two weeks' tour of the ceramic plants of Scandinavia.

The group will visit Scandinavian plants which manufacture refractory goods, building brick, roofing tile, and pottery. The tour was organized by J. W. Mellor of the Ceramic Society [England]. Arrangements for the inspection of plants are being made by A. S. W. Odelberg of Gustavsburg, Sweden, and Dr. Andreasen of Copenhagen.—J. J. R.

COMMUNICATIONS

TANK COOLING BY USE OF AIR*

By R. R. Robinson

Since either water or air may be used in the cooling of glass tanks, the selection of a method should be a matter of economy. My experience has been with air cooling.

I have in mind a problem in which a tank of large size is being cooled with a power consumption of less than 30 horse-power input to the motor.

The tank is 82 ft. long and 24 ft. wide with approximately 200 sq. ft. of surface to be cooled.

The ducts conducting the air lead from a fan (set on a platform outside the factory building at an elevation 5 ft. above the top of the tank) over the tank and drop to the various points to be cooled.

A recent test gave the following results:

Temperature of atmosphere entering fan: dry bulb 80.5°F—wet bulb 60.5°F
Barometer, 29.132 in. Hg
Air density, 0.071415 lb./cu. ft.

Av. static pressure main duct	2.5400 in.
Av. velocity pressure	0.5011 in.
Total pressure	3.0411 in.

$$\text{Velocity} = 1096.2 \times \sqrt{\frac{0.5011}{0.07141}} = 2900 \text{ ft./min.}$$

Diameter of duct where readings were taken = 48 in.

Area of duct where readings were taken = 12.57 sq. ft.
$2900 \times 12.57 = 36{,}400$ cu. ft./min.

$$\frac{136{,}400 \times 3.04 \times 5.2}{33{,}000} = 17.4 \text{ air h.p. or total h.p. developed by fan}$$

Motor, 30 h.p.
Power input to motor = 18.5 kw. or 24.8 h.p.
Motor efficiency, 90%
Belt efficiency, 98%
$24.8 \times 0.90 \times 0.98 = 21.88$ boiler h.p. or h.p. applied to fan shaft

$$\frac{17.4}{21.88} = 0.795 \text{ or } 79.5\% \text{ fan efficiency (total)}$$

The pressures at the nozzles where the air was discharged against the tank blocks were as follows:

Air temp. entering fan	Air temp. emerging from nozzle (°F)		Pressure at base of nozzle (in.) Static	Total	Pressure** at nozzle outlet
80.5°F	(reading)	100	1.0	1.50	1.400
	(calculated)	80.5	1.055	1.58	1.478

The nozzle readings were taken at the end of the longest run of duct so as to obtain maximum pressure drop of the system. To determine the actual pressure drop in the system, the nozzle pressures were calculated for the temperature of the entering air. The rise of 19.5°F was due to heating of the duct by radiation from the tank.

Humidification of the air was considered, but it was found that unless water should be carried to the tank walls as a liquid spray, the heat-absorbing ability of the air would be but slightly increased. If the latent heat of evaporation could be employed, water spray would be valuable. However, since the effect upon the physical structure of the blocks was not known, spraying was not used.

The table below shows the performance of the system with different quantities of air and with air having density as found in test and when the atmospheric temperature is 0°F.

It is difficult to make a comparison of costs for water- and air-cooling because of the variation of water costs. Water costs are affected by the distance and uniformity of supply and by the chemical content of the water.

Since the cooling of tank walls increases the life of the blocks, it is reasonable to assume that the cooling of the bottom would have similar results. Many glass operators, however, have been reluctant to employ this type of cooling, because, as has been explained, extraction of heat increases fuel consumption. However, the difficulty has not been due to the principle but rather to the lack of proper data concerning heat conductivity and the failure to conform with the natural laws controlling absorption of heat by air.

Fan Performance

Motor pulley (in.)	Rev./min.	Cu. ft./min.	Pressure Static (in.)	Pressure Total (in.) N_2O	Density	Total eff. (%)	Brake h.p.	Input h.p.	Overall motor and belt eff. (%)
10	644	36,400	2.54	3.04	0.07141	79.5	21.88	24.8	88.25
11	709	40,000	3.07	3.575	0.07141	79.5	28.18	31.9	88.25
11	709	40,000	3.61	4.19	0.084	79.5	33.22	37.65	88.25

Nozzle Pressure

Fan (r.p.m.)	Temp. (°F)	Static (in.) N_2O	Total (in.) N_2O
644	100	1.00	1.50
	80.5	1.055	1.58
709	100	1.22	1.82
	80.5	1.29	1.92

Robinson Ventilating Co.
Zelienople, Pa.

* Discussion of "Water Jackets for Glassmelting Tanks" by L. T. Sherwood, *The Bulletin*, pp. 119–20 (March, 1935). Received February 22, 1935.

** This pressure is all velocity pressure. There may have been some error in reading due to the difficulty of getting the instrument placed properly.

AIR COOLING OF TANK BOTTOMS

I am pleased that R. R. Robinson has made this contribution to the subject, since among other things more information is needed about air cooling of tank bottoms, a purpose for which water jackets are scarcely applicable.

In a case in question it would be useful if an installation of air cooling could be designed to assure a specified increase in the life of the bottom blocks or, vice versa, if the extension of block life from specified air cooling could be reliably approximated. It seems that information of this kind is, after all, what the glass manufacturer would like to have. If Mr. Robinson or others can furnish it, I think the industry would be appreciative.

—L. T. Sherwood

THE PROBLEM OF MALLEABLE GLASS*

By James Bailey

I. Introduction to the Problem

The term "malleable" implies that the material may be hammered, bent, twisted, and otherwise abused without being broken. It is necessarily a relative term. In these respects it is more or less synonymous with such terms as "nonbreakable" and "shock-resisting" which better represent the properties we desire in glass.

Shock-Resisting Power

It has long been recognized that the shock-resisting power of a metal is an important constant of the material. There are several standard tests for this property known as the "Izod" impact test, the "Charpy" test, and the "Stanton" test.[1]

Note: The specimens are all small. The Izod specimen is approximately 3 in. long and has a section of 0.155 sq. in. It is notched on the tension side, the section under the notch being 0.124 sq. in. The specimen is clamped vertically in a heavy vise with the notch flush with the jaws. A heavy pendulum swings against the upper end of the notched side of the specimen either bending it over or breaking it off. The foot-pounds of work are measured from the constants of the pendulum and the variation of the swing before and after contact. The notch and the vise confine the amount of metal actually tested to something like 0.01 cu. in. Owing to vibration, friction, etc., the result cannot be reduced to work absorbed per cubic inch of material.

It is not possible to discuss a subject so involved as the possibility of producing a nonbreakable ceramic glass without a comprehensive treatment of all the physical characteristics which enter into such a discussion. An idea of the magnitude of the problem and of the hopelessness of producing a nonbreakable silicate glass may be gathered from the following very brief outline.

Factors Involved

When any moving object collides with another object, a sudden readjustment of the energy contents of the objects must take place. The picture is simplified if we imagine an article dropped from a certain height onto a heavy structure such as a floor. At the instant the article touches the floor, the article will have an energy content equal to its weight times the height of the fall. This energy must be completely absorbed in one or more of several ways, as (*a*) elastic deformation of itself and the floor, (*b*) plastic deformation of itself and the floor, or (*c*) friction of the surfaces, etc. The elastic deformation will be given back to the article and will cause the article to bounce up again. If the floor is soft, the energy may be absorbed quite completely by denting the floor. In the case of a hard floor, such as stone or concrete, most of the energy must be absorbed by the falling article itself. Thus, if a chunk of wood is dropped onto a solid floor it will be marred by the impact; an iron bar will be scratched, dented, and perhaps bent; a rubber ball will bounce back apparently without injury as also will a steel spring if the end of the spring contacts first, etc.

More Obscure Factors

From this point on, the factors involved become more and more obscure and it is not possible to make a definite solution of any general case. It is evident, however, that the energy to be absorbed will vary throughout the colliding objects; *e.g.*, a long slender bar falling axially against the floor will be stressed a maximum at the contacting surface and will have no stress induced in the uppermost end. There will be some secondary vibrational stresses of course. This comes about because each section must arrest the motion of the mass back of that section. Likewise, the stress induced at the contacting end will approach infinity if the area is small and the material cannot distort. We are all familiar with the fact that an iron rod a foot long may be "upset" by being pounded on the end with a hammer while it is held in the hand. This is evidence that the stresses induced have been greater than the yield point of the material which is of the order of 40,000 lb. per sq. in. in most bar iron. In practice, the stresses induced in the contacting areas will, under certain conditions, exceed any assigned value when one moving object collides with a massive rigid structure. Whether or not the article can withstand the collision without fracture depends upon the ability of the material to deform enough to relieve the pressure. Careful thought will show that under identical conditions of shape, weight, velocity of impact, etc., the nonbreakability of an article depends upon the work-absorbing power of the material from which the article is made.

Plastic Flow

If T is the ultimate tensile strength of the material, Y is the yield point, and E is Young's modulus of elasticity, then the work of elastic deformation W_E is

$$W_E = \frac{Y^2}{2E} \qquad (1)$$

After the yield point has been reached, the material may flow plastically. The plastic flow depends upon the rate of applied pressure and several other factors. Usually in metals the flow results in an increase of the yield point as the elongation increases, until the stress has reached the ultimate tensile strength, S, when it ruptures. The work W_P of this part of the deformation is approximately

$$W_P = \frac{Y + S}{2} X \qquad (2)$$

Where X = measured elongation.

Note: The specimen is marked before testing. After the break the pieces are removed from the testing machine, fitted together, and remeasured. The elongation is the difference in distance between reference marks figured in per cent.

* Received March 8, 1935

[1] *Nickel Steel Topics*, **2** [3], 11 (June, 1933). International Nickel Co.

Since the ends can not be accurately fitted together the measured elongation is somewhat too long, but the work absorption figured from the above formula is nevertheless too small because the average value of stress after the yield point has been reached is higher than the mean between the yield point and the ultimate strength. The error in the formula is probably about -5% in most cases.

II. Work Absorption of Various Materials

These formulas enable the approximate work absorption of various materials to be computed. The data taken below are from standard handbooks except where otherwise stated.

1. Metals*

Commercial wrought iron

Yield point, 30,000.
Ultimate strength, 55,000.
Elongation in 2 in., 35%.
Modulus of elasticity, 17.5×10^6.
Work of elastic deformation, 25.7 in.-lb./cu. in.
Work of plastic deformation, 15,000 in.-lb./cu. in.

Steel SAE 3340 Heat-Treated

Yield point, 170,000.
Ultimate strength, 232,000.
Elongation in 2 in., 18%.
Modulus of elasticity, 30×10^6.
Work of elastic deformation, 480 in.-lb./cu. in.
Work of plastic deformation 36,180 in.-lb./cu. in.

Cast Brass

Yield point, 21,800.
Ultimate strength, 45,800.
Elongation in 2 in., 15%.
Modulus of elasticity, 13×10^6.
Work of elastic deformation 18.2 in.-lb./cu. in.
Work of plastic deformation 5080 in.-lb./cu. in.

Monel Metal (av. of several values)

Yield point, 80,000.
Ultimate strength, 110,000.
Elongation in 2 in., 35%.
Modulus of elasticity, 26×10^6.
Work of elastic deformation, 123 in.-lb./cu. in.
Work of plastic deformation 33,200 in.-lb./cu. in.

2. Nonmetallic Materials

Of the nonmetallic materials rubber is unique in that it has the ability to elongate to about six or more times its initial length before rupturing. The stress-strain relation is not straight, however, so that the formulas previously applied can not be used. It is necessary to plot the stress-strain graph and determine the work by the area under this graph. This has been done in rubber compound No. 514.

Rubber compound[2] No. 514

Stress at 300% elongation, 15.8 kg./sq. cm.
Stress at 500% elongation, 31.6 " " "
Stress at 700% elongation, 84.4 " " "
Ultimate tensile strength, 257.0 " " "
Elongation at break 950%
Computed work of elastic deformation, 8000 in.-lb./cu. in.

Cellulose Nitrate Plastic[3]

Tensile strength, 4000–10,000.
Elongation, 5 to 30%.
Modulus of elasticity, 2 to 3.9×10^6 lb./sq. in.

It is not possible to determine the work-absorbing power directly from the above figures because the yield point is not given. It is evident, however, that the ability of this material to absorb work would be limited between 600 in.-lb. and about 2800 in.-lb. per cu. in.

3. Ceramic Materials

All calcined ceramic materials lack ductility. They deform elastically until the ultimate strength is reached when rupture occurs suddenly without any apparent flow. This behavior is characteristic of all vitrified bodies and becomes more and more apparent as the glassy state progresses. In the case of glass, the most refined methods have failed to detect any plastic flow whatever. The first formula may therefore be used for computing the work absorption in which the value for V is the ultimate strength.

NOTE: Some sandstones and certain other porous minerals exhibit some anomalous deformation. Some fibrous minerals such as asbestos also exhibit slipping prior to rupture somewhat similar to plastic flow. The work absorption due to these causes is small.

NOTE: The term "resilience" has been used to express the energy absorbed during elastic deformation. The term may be used to express the work absorbed in breaking a piece of glass. The term "work absorption" is self-evident and includes all of the work required to break a specimen whether it is elastic or plastic.

The elastic deformation is so small that it is difficult to measure. The tensile strength is also difficult to measure directly so that the measurements on ceramic materials are usually made in the form of bending tests, and the modulus of elasticity is a combination of the tension and compression strains induced. Its value is directly comparable to that obtained by testing in direct tension.

The indicated maximum tensile strength found by bending is called the modulus of rupture. The work-absorbing ability of various ceramic products computed from bending tests is as follows:

*Stoneware**

Modulus of rupture, 5900 to 12,500.
Modulus of elasticity, 1.05 to 5.95×10^6.
Work of elastic deformation, 2.9 to 78 in.-lb./cu. in.

It is probable that the maximum strength and minimum modulus of elasticity can never occur in the same piece so that the figure of 78 in.-lb. is considerably too high.

Porcelain[4]

This material varies with the composition and firing. Pender[4] gives 1500 to 2200 tensile strength and 2.5×10^6 for the modulus of elasticity. This gives the maximum

* All figures in lb. per sq. in. unless otherwise specified.
[2] *Ind. Eng. Chem.*, **25**, 280 (1933).
[3] Perry, Chem. Eng. Handbook, p. 1774. McGraw-Hill Book Co.
[4] Harold Pender, Handbook Electrical Engineering, p. 819, 1st ed., John Wiley and Sons, Inc.

work of elastic deformation as 9.7 in.-lb. per cu. in. The figures are probably slightly low for the best grades of porcelain.

Glass

The tensile strength for glass is variously quoted from 2500 to 10,000 lb. per sq. in. The modulus of elasticity is about 8 million lb. per sq. in. These figures give a range of work of elastic deformation 0.4 to 6.0 in.-lb.

The figures for strength and elasticity given by Hovestadt[5] range from 3.5 to 8.5 kg. per sq. mm. in tensile strength and from 60 to 126 kg. per sq. mm. in compressive strength. The modulus of elasticity covers the range 5100 kg. per sq. mm. to 8000 kg. per sq. mm.

The maximum tensile strength of any glass was 8.5 kg. per sq. mm. (12,060 lb. per sq. in.) and the minimum modulus of elasticity was 4700 kg. per sq. mm. (6,674,000 lb. per sq. in.). These figures give a work absorption of 10.9 in.-lb.

According to Littleton,[6] internally strained glass may show an internal strain corresponding to a tension of about 30,000 lb. per sq. in. If this strength could be realized throughout it would increase the work of elastic deformation to 67.5 in.-lb. per cu. in. when rupture occurred. Nothing like this has ever been obtained in actual tests.

To sum up the above, about all that can be expected from annealed glass is a maximum work-absorbing power of 10 in.-lb. per cu. in. By heat treatment, *i.e.*, suddenly chilling from the plastic state or "case hardening," the limit theoretically possible is a work absorption of less than 70 in.-lb. per cu. in.

III. Possibilities of Nonbreakable Glass Remote

All of the above figures have been based upon the tensile strength in all materials. It may be argued that in cases of impact the real stress is always one of compression. There is some ground for such a belief, but it must be remembered that the laws of elasticity require that any strain in one direction produces strain in both other perpendicular directions. These are connected numerically by Poisson's ratio in all isotropic bodies. Since Poisson's ratio is given values between 0.16 and 0.32 for glass and ceramic bodies, the work-absorbing power of a nonplastic material in compression could never exceed about 3 to 6 times its value figured in tension.

If plastic flow can take place, the work-absorbing power increases enormously in compression because the section increases and much greater deformation is possible before rupture takes place.

What "case hardening" or "toughening" glass really does is to so arrange the stresses that the severe concentrations take place in a layer already under compression and the tensile stresses, which easily produce rupture, are partly neutralized by the initial stress. It is a rule of engineering that the weakest ultimate breaking stress must be used in all calculations wherever safety is involved. Therefore, the work-absorbing ability should be computed for the tensile stresses in all ceramic products.

The above figures were given with the idea of showing that the resistance of the material to mechanical shock is due almost entirely to the ability of the material to flow when the yield point has been reached. Thus the metals can absorb from 200 to 600 times as much work during plastic flow as they can elastically. The case of rubber is peculiar in that its flow is neither elastic nor plastic since its modulus of elasticity continually changes with load. The deformation may, however, for the purpose of this article, be considered to be of an elastic type, with its work-absorbing power due primarily to a low modulus of elasticity, rubber being about 360 times more pliable than glass.

It is evident that glass must have a tensile strength about 30 times what is now found by actual tests if it is to absorb work by its elastic deformation in amounts comparable to the metals, or it must have a modulus of elasticity of the order of seven thousandths (0.007) of its present value or else it must have a plastic flow greater than that of the metals. Heat treatment of glass can increase its apparent strength only in the ratio of about 3 to 1.

Composition and Work Absorption

All of the chemical elements have been tried in glass. There is chance for further work in this line, but no ingredient has ever been found that would seem to offer promise of changing the work absorption to more than a small multiple of the value usually found. As an example, it has been shown that zirconium will reduce the modulus of elasticity to about half with proper additions to the right base batch.

It might be added that X-ray studies show that the molecular arrangement of all inorganic glasses thus far studied is of an entirely different type from that of the materials showing plasticity.

Further, all the metallic oxides, whether in the crystalline state or fused and chilled without crystallizing, as in glass, are inherently brittle substances showing no appreciable flow. Certainly there is no indication anywhere that a structure having work-absorbing ability in appreciable amounts can be made up from the inorganic oxides.

A perusal of the physical properties of the silicate minerals shows that none of them fall outside of the range given above for ceramic materials.

Transparent Metal

It seems that it would be just as possible to develop a transparent metal as it would be to develop a ductile glass. One is as logical as the other; for instance, thin layers of silver and gold will transmit measurable amounts of light.

IV. Possible Lines of Attack

While it appears that glass can not be made ductile or plastic, much can be done to increase its serviceability. Porcelain is weaker than glass but it will withstand rough usage better than ordinary annealed glass. This is because it does not have a homogeneous structure. A crack started in porcelain or china can not spread easily. The end of the crack encounters vast numbers of minute par-

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[5] Hovestadt, Jena Glass. Translated by Everett. Macmillan Co.

[6] J. T. Littleton, Jr., and F. W. Preston, "A Theory of the Strength of Thermally Toughened Glass," *Jour. Soc. Glass Tech.* (*Trans.*), **13** [52], 349 (1929).

ticles which tend to divert its path. Hence the material usually chips away and thus confines the injury to a small area. Clay products exhibit this tendency to a marked degree when the firing is carried to the proper point. The old rattler test on paving brick may be cited.

Mixing Dissimilar Glasses

It seems likely that the destructive effect of mechanical shocks on glass might be reduced by mixing two dissimilar glasses. Thus if two dissimilar glasses were mixed together and stirred but not allowed to homogenize, each component glass would be surrounded by a fine network of strains. A crack tending to spread in such a glass matrix would encounter regions of tension and compression which would tend to divert the spread of the crack in much the same way as does the structure of porcelain.

Heat-resisting glass owes its ability to withstand thermal shock to the fact that its coefficient of expansion is low. A glass contracting from one temperature to another will do work on the surrounding constraining glass. The work done is directly proportional to the coefficient of expansion and the difference in temperature. If this work is within the work-absorbing ability of the glass no fracture will result. A low coefficient of expansion means that the work-absorbing power of the glass may be less for the same permissible temperature change or that the temperature change may be greater before rupture occurs. The whole matter resolves itself again into the ability of the material to absorb work. Thermal shock is in many ways quite similar to mechanical shock.

Plasticizing

Many of the synthetic resins are very brittle when pure. The proper amount of plasticizer added to these will produce a material which is no longer brittle and which will show considerable resistance to shock. It might be argued that a glass could be compounded along similar lines. A common glass might be plasticized by the addition of a glass which was a liquid at room temperatures. The difficulty here is obvious. There is no glass which is liquid at anything like room temperatures.

There are several other methods of attack which lead to the conclusion that a ceramic glass can not have plasticity or ductility. These are too involved for presentation in a brief elemental discussion such as this.

Problem of First Order

It is never safe to say that something can not be done. My purpose is to show that the production of a ductile or malleable glass is a problem of the first order and will require materials and technique at present unknown before it can be solved. If this sketchy outline provokes discussion and thought upon this great problem, it will have served its purpose.

After all, glass is one of the most useful materials we have. What other material lends itself so readily to the craftsman's art? What other material can be so easily formed into bottles, flasks, and the like? What other material is so brilliant, so permanent against decay, so transparent, and withal so cheap? We can not expect all the good qualities of other materials to exist in this one branch of our endeavor.

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MALLEABLE GLASS (*continued*) *

With great interest I have read James Bailey's article, "Ductile Glass" in which he considers that it is physically impossible to make and futile to hope for a glass having the property of deformation under shock, and that the inference should not be made that ductile glass was ever manufactured.

The contrasting opinion of R. Gregory[1] is of more than academic interest. It is as follows:

> Among the special glasses represented in the exhibition and typical of new developments are the heat-resisting glasses for chemical apparatus and domestic ware. The production of these and other new glasses may perhaps justify the suggestion that malleable glass is not beyond the bounds of possibility.

The problem of "unbreakable," "malleable," "ductile," "toughened," "hardened," etc., glasses has been one of the most important problems of the glass industry both ancient and modern.

If the American Ceramic Society could focus the attention of the glass technologists and chemists on this unique problem by (1) gathering papers and opinions on this subject, (2) including this question in the plan of a future meeting of the Glass Division of the Society and the International Commission on Glass, or (3) opening a special discussion in the pages of *The Bulletin*, I am sure the coördinated scientific efforts would help summarize the experience and experiments, clear up the question, and further our knowledge in this basic and fascinating field of the glass industry.—SELICK I. PERKAL.

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* For previous discussion see *The Bulletin*, p. 351 (December, 1934).

[1] *Jour. Soc. Glass Tech.*, **15** [59], 81 (1931).

Malleable Glass of Tiberius May Have Been Horn-Silver

In looking over the December *Bulletin*, I note on p. 35, the comments on malleable and ductile glass by Perkal and Bailey, respectively. It is my impression that the mineral chlorargyrite (or horn-silver) occurred in the Roman Empire. This is silver chloride. It is my further impression that silver chloride may be melted and cooled to a glassy mass which is malleable. There is, of course, the possibility that the malleable glass of the time of Tiberius happened to be a good sized chunk of horn-silver which the artificer was able to hammer into shape.

—ALEXANDER SILVERMAN

ELECTRIC KILNS FIRED SUCCESSFULLY*

By Charles W. Speirs

A. S. W. Odelberg and I discussed the use of electric kilns during his recent visit to England. Our joint visit to the United States of America some years ago was a bitter disappointment to us because at that time we failed entirely to interest any one there in what we then believed, and still believe, to be the future method of firing.

The subject is too large to discuss in a letter, but the following facts deserve consideration.

My firm, crucible and carbon brush manufacturers, favors developing the manufacture of large high-temperature resistors. They would not give the time, however, to the erection of kilns which was quite outside their line of business.

We have used our resistors in special electric kilns for many years in our own business, but each type of kiln requires special consideration and as I obtained no encouragement in the United States, we gave up all idea of developing pottery kilns.

I believe the efficiency depends partly on the type, shape, and size of the resistor, and as the Morgan resistor is made in large sizes (up to 7 ft. by 2 ft. by 1 in. thick) it is particularly suitable to give excellent heating conditions both by radiation and convection.

A resistor at the center or sides and center of the kiln (*i.e.*, 12 in. high) and placed opposite the lower half of a truck loaded (*i.e.*, 24 in. high) has given extremely even temperature throughout all the ware on a truck 6 ft. long, the ware being 15 in. deep and 2 ft. 3 in. high. We are satisfied that there is a strong movement of air up between the outside of the resistor and the wall of the kiln and down through the ware on the truck.

Odelberg's electric kilns, which have been running nearly ten years, can be classed as "toasters" as they are used only for glost firing, but they turn out ware of one quality with never more than 2 or 3% "seconds." Even this percentage is not the result of firing.

Our largest electric kiln at Battersea fires small carbon rods packed in clay saggers (in carbon dust) about 15 in. in diameter and 18 in. high. As carbon dust is a poor conductor and the rods are all excellently heat-treated, this can not be called "toasting." The temperature inside the sagger is about 1250°C. We get more even results from this kiln than from a large gas-fired kiln of the Mendheim type.

The only other kiln of any size and temperature erected by us was for Royal Doulton at Lambeth. The truck was 6 ft. long, 15 in. wide, and the ware was set about 2 ft. 3 in. high. Thick porcelain insulators have been fired in this kiln.

I believe that one of the reasons for the good results obtained in our electrical kiln is the result of the even rise and fall of temperature controlled by each kiln having double tracks, one track controlling the heating or cooling of the other track.

The Chesters, Traps Lane
New Malden
Surrey, England

* Received February 23, 1935.

PERSIAN POTTERY OF ANCIENT TIMES*

Although our knowledge of the origins of early pottery techniques is scanty enough to allow almost unlimited theorizing, it is certain that in Persia during the last seven or eight thousand years there has been a great variety of fresh and interesting pottery types produced.

The earliest pottery discovered of either the neolithic or early bronze age is a thick ware, low fired, hand shaped, plant tempered, and is decorated with geometric designs painted in a single color, usually red. After the painting, the surface was sometimes hand-burnished. This pottery was followed by a harder, thinner variety with a slip. The wheel came into use, and naturalistic designs began to develop. Various animals, ibex, birds, and others are shown in motion. The shapes of the vessels show delicately molded curves, and the material is thin and hard enough to give a high tone when struck. Pottery of this type was found at Damghan in northeast Persia by the University of Pennsylvania Museum Expedition.

After this period came cultures with gray-black unpainted pottery.

The Islamic pottery of Persia is well represented in several European and American museums, but there have been no publications accurately describing and dating it. The Islamic pottery before the invasion by Tamerlane in 1306 A.D. may be divided roughly into two types.

The earlier type was made when Persia was under the control of the Abasid Caliphate. Its designs and shapes are related to the pottery found at Samara, which should be typical of 10th Century Mesopotamian. The Samara ware is similar to imported Chinese ware found with it.

In Persia the ware had characteristically a buff to reddish body, covered by a slip containing tin oxide, through which the designs were sometimes drawn. Over this a lead glaze was used, often colored with copper or manganese salts. Graffito work in this type of pottery was beautifully developed in what is known as Gabri pottery which was made in the Caspian provinces. The finest pieces are decorated with large, boldly drawn animals.

The second type seems to have begun with the rise of the influence of the Seljuqs in Persia, some time during the 11th Century. It is a low-fired porcelain, the body is of sand bonded with glass, and the glaze is alkaline. Luster and Minai ware are in this class.—George W. Brainerd

* Presented at a joint meeting of the Central Ohio Section and the O. S. U. Student Branch of the Society. Received March 15, 1935.

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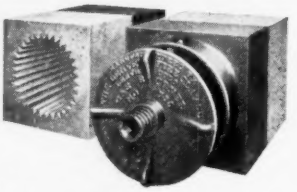

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Bonnot Co.
Clay (Sagger)
Edgar Brothers Co.
The Hommel Co., O., Inc.
Kentucky-Tennessee Clay Co.
Paper Makers Importing Co
Pittsburgh Plate Glass Co.
Potters Supply Co
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Clay (Wad)
Kentucky-Tennessee Clay Co.
Potters Supply Co.
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Clay (Wall Tile)
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Ferro Enamel Corp.
The Hommel Co., O., Inc.
Jungmann & Co., Inc.
The Roessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.
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Drakenfeld & Co., B. F.
Ferro Enamel Corp.
The Hommel Co., O., Inc.
Pittsburgh Plate Glass Co.
TheRoessler & Hasslacher Chemical Co.
The Vitro Mfg. Co.
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Norton Co.
Porcelain Enamel & Mfg. Co.

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Enameling Muffles
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Norton Co. (*Alundum*)
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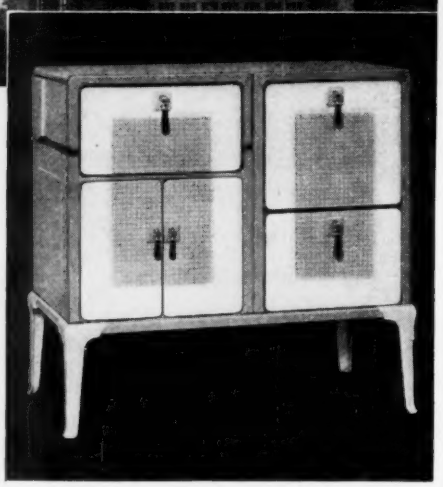

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Cerium Hydrate
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Clay, Vallendar
Cobalt Oxide, Black
Cobalt Sulphate
Copper Oxides
Didymium Oxalate
Iron Chromate
Iron Oxides
Kryolith
Lead Chromate
Magnesium Carbonate
Manganese Dioxide
Mercuric Oxide
Neodymium Oxalate
Nickel Oxide, Black
Nickel Oxide, Grey
Nickel Sulphate
Potassium Bichromate
Potassium Nitrate
Potassium Permanganate
Powder Blue
Rutile, Powdered
Selenium
Sodium Antimonate
Sodium Bichromate
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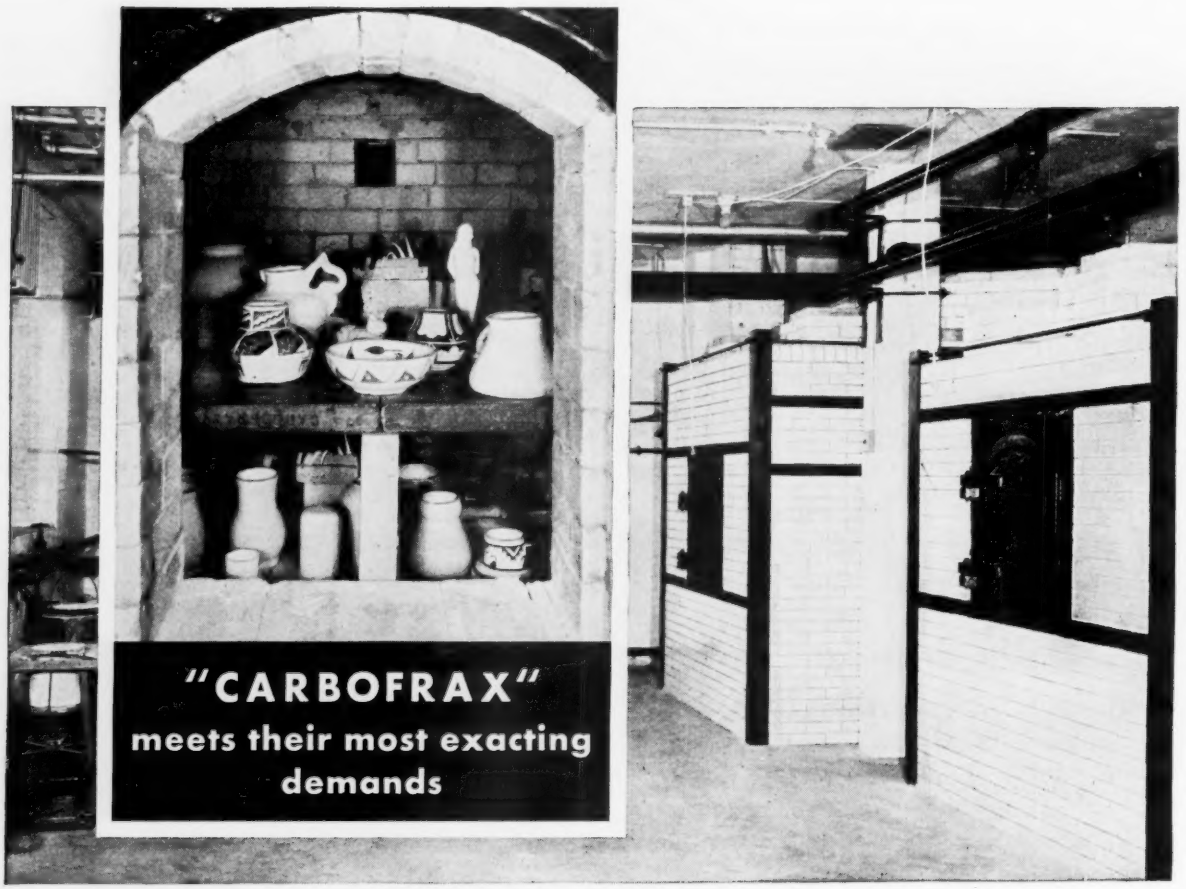

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As to how to make a profit ! ! I have talked it over with Clayton, our Trainer, and he says our entries are running true to form, and I tell you a bet on those three tough boys—JERNIGAN BALL, or the CHAMPION and CHALLENGER entry is good any day anywhere. If it turns really warm and it's heat you are afraid of, try one of these—BLACK WAD—TAN WAD—GLEASON SAGGER—or JERNIGAN SAGGER—they can take it !

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